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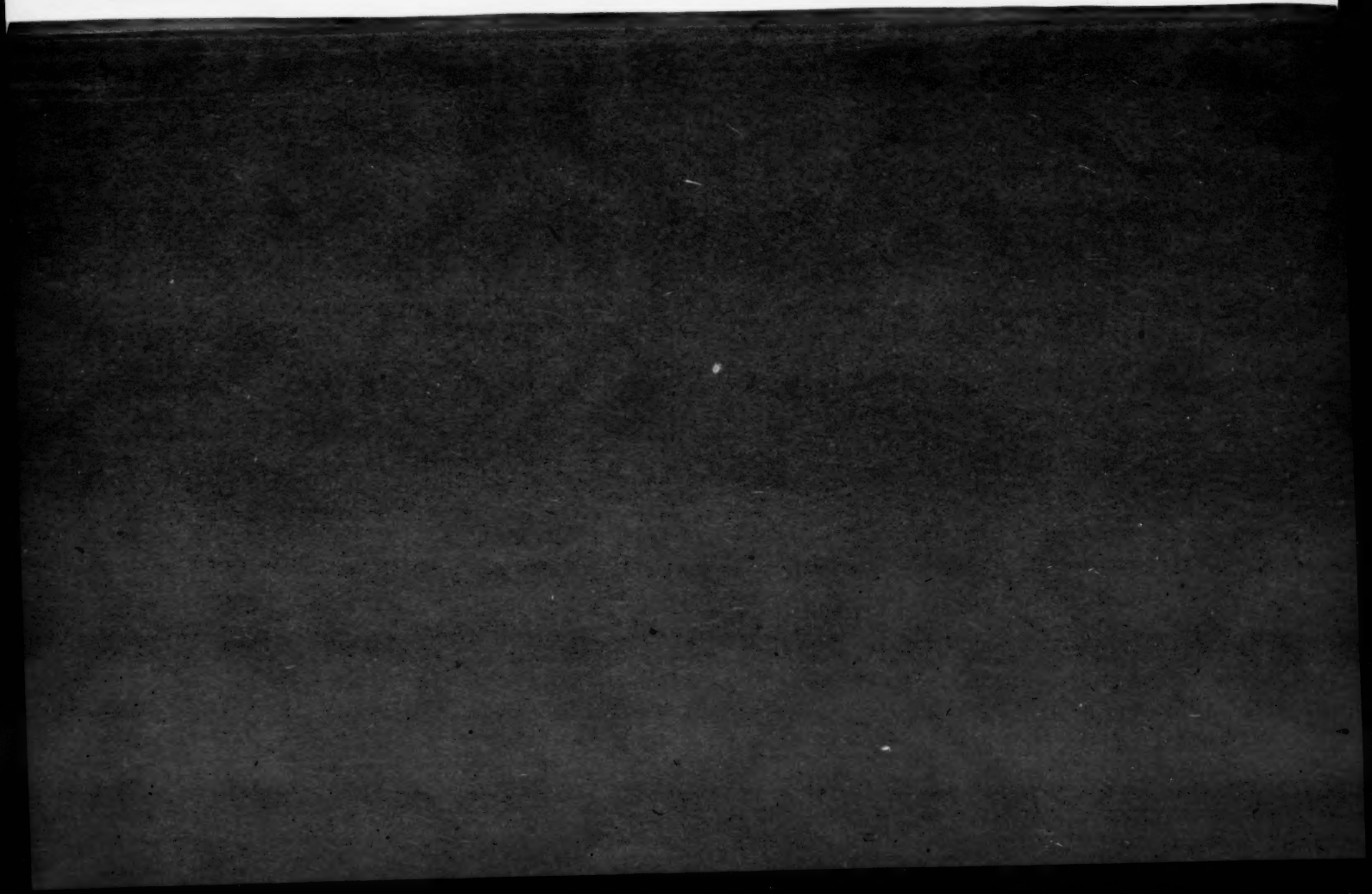

NOTES ON CINCINNATIAN FOSSIL TYPES

AUG. F. FOERSTE

The more exact study of the stratigraphy of the Cincinnatian formations requires a closer discrimination of fossil species and varieties than was thought necessary formerly, when the entire series of Cincinnatian strata was regarded as fairly homogeneous, not only lithologically but also in fossil content. However, a closer discrimination of fossil species and varieties requires a more definite knowledge of the limits to be assigned to the forms already described, and for this purpose an accurate knowledge of the characteristics of the described and figured types is desirable. It was in order to secure this knowledge that the series of studies of Cincinnatian fossils published in this Bulletin, and of which the present is another contribution, was undertaken. It is not intended in these studies to revive the names of all the so-called species here discussed. Many of these names have been discarded happily long ago. It is regarded desirable, however, to place on record exactly what all of the so-called species are, giving, wherever possible, illustrations of the figured types, produced by photographic methods. In some cases the study of the type material has not resulted in definite conclusions, but it is hoped that, even in their present imperfect condition, these notes may be found serviceable.

On the following pages, in order to facilitate reference to these types, the original specific term applied to the type is retained as a heading even in those cases in which there is every reason to believe that this term is merely a synonym of some earlier described species. The generic reference however is altered whenever necessary in order to conform with present usage. This should lead to no confusion, since all available information, suggesting synonomy, is embodied in the accompanying text.

1. Pasceolus claudei Miller
2. Pasceolus tumidus James
3. Dystactospongia madisonensis Foerste
4. Dystactospongia (?) cavernosa n. sp.
5. Leptopoterion faberi Miller
6. Protaraea vetusta Hall

7. Calapoecia cribriformis Nicholson
8. Tetradium ontario Hall
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11. Dermatostroma glyptum Foerste
12. Stromatocerium granulosum James
13. Stromatocerium montiferum Ulrich
14. Stromatocerium indianense James
15. Stromatocerium huronense australe Parks
16. Lingula covingtonensis Hall and Whitfield
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Craniae of the Richmond group

21. Crania scabiosa Hall
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Craniae from the Economy member of the Richmond group

26. Crania dyeri Miller
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29. Crania socialis Ulrich
30. Crania albersi Miller and Faber

31. Whitella cuneiformis Miller
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33. Cyrtodonta cuneata Miller
34. Anomalodonta alata Meek
35. Anomalodonta costata Meek
36. Byssonychia robusta Miller
37. Cymatonota cylindrica Miller and Faber
38. Modiolopsis versaillesensis Miller
39. Modiolopsis brevantica n. sp.
40. Pholadomorpha pholadiformis Hall
41. Pholadomorpha divaricata Hall and Whitfield.
42. Pholadomorpha capax Miller
43. Pholadomorpha corrugata Miller and Faber
44. Pholadomorpha sulcata Miller and Faber
45. Rhytimya cymbula Miller and Faber
46. Vallatotheca manitoulini Foerste
47. Endoceras arcuatum James, J. F.
48. Caliculospongia pauper, gen. et sp. nov.
49. Carneyella and Isorophus, gen. nov.

1. **Pasceolus claudei, Miller**

Plate III, Figure 2

1874. Pasceolus claudei Miller, Cincinnati Quart. Jour. Sci., vol. I, p. 6, Fig. 3

The cotypes at present form No. 8837 in the Faber collection in the Museum at Chicago University. Of these, one resembles in size and form the figure accompanying the original description, and this specimen is here illustrated. The general outline of the surface plates, as determined from the concave depressions left behind on this cast of the interior of the organism, was hexagonal rather than pentagonal. The absence of a depression at the base of the specimen evidently is not a distinctive characteristic since a specimen of *Pasceolus claudei* in the Dyer collection at Harvard University shows such a depression. Specimens with surface plates intermediate in size between those of typical *Pasceolus claudei* and *Pasceolus darwini* occur at the type locality and horizon: 2 miles south of Maysville, Kentucky, along the railway, at the base of the Bellevue member of the Maysville. It is not certain whether *Pasceolus claudei* is to be regarded merely as the young of *Pasceolus darwini*, or as a distinct species. It is assumed that the exterior surface of the surface plates was concave, as in *Pasceolus darwini*.

2. **Pasceolus tumidus,** James

(Plate III, Fig. 1)

1878. Astylospongia tumidus James, Paleontologist, 1, p. 1

1891. Pasceolus (?) tumidus James. Jour. Cincinnati Soc. Nat. Hist., 14, p. 59, Fig. 3

The cotypes at present form No. 1222 in the James collection in the Museum at Chicago University, and are labelled as coming from an elevation of 350 feet above low water in the Ohio river at Cincinnati. This should place them approximately in the upper part of the Fairmount member of the Maysville.

The surface plates have an hexagonal outline. Three plates occupy a width of 6 millimeters. The exterior surface of the plates is concave, and distinct grooves extend from the angles toward the center, toward which they widen and at which they coalesce. The depressions left by these plates, where they have weathered away, are concave. There is no indication of a short spine extending from the center of the inner surface of these plates toward the interior of the spherical space which these plates surround; nor

is there any evidence of the individual plates being hollow and there scarcely is room for such a hollow space between the exterior and interior surfaces of these plates. The general form of the specimens is subglobose, more or less depressed, with a depression on that side usually regarded as the base. The stellate grooves were first described and figured by Joseph F. James, the son of the original describer, and one of the cotypes preserving these features to a marked degree is here illustrated.

Similar stellate markings have been found on the exterior surface of the plates in specimens of *Pasceolus darwini* Miller, at the base of the Bellevue member of the Maysville, 2 miles south of Maysville, Kentucky, along the railway. In fact, stellate markings occur on a plate preserved on one of the cotypes of this species at present in the Faber collection at Chicago University, and obtained at this locality and horizon. This series of cotypes is numbered 8838, and is assumed to include also the specimens figured in the original description of *Pasceolus darwini*.

In his original description of *Pasceolus darwini* (1874, Cincinnati Quart. Jour. Sci., 1, p. 5, figs. 1, 2), Miller states that fragments and poor specimens occur also on the hills back of Cincinnati, at an elevation of about 400 feet above low water mark. This may correspond to the Bellevue horizon, *Pasceolus tumidus* having been described by James from about 350 feet above low water.

An examination of numerous specimens of *Pasceolus* from the middle of the Maysville in Kentucky and Ohio suggests that *Pasceolus darwini*, *Pasceolus claudei*, and *Pasceolus tumidus* all belong to the same species. They all contain from 15 to 17 plates along a line drawn transversely across the so-called upper surface of the specimen, indicating that from 30 to 35 of these plates should occur along a great circle surrounding the subglobose specimens. From this it is evident that difference in the size of the plates is due to a corresponding difference in the size of the entire specimen, and suggests a difference in the stage of growth of the individuals, rather than a specific difference. In a similar manner, only the larger specimens, from 25 to 30 millimeters in diameter usually present the distinct but rather shallow depressions on that side usually regarded as the base of the specimen, while specimens from 20 to 25 millimeters in diameter usually show only a faint trace of this basal depression, and on still smaller specimens this depression usually is absent.

That the concave curvature and stellate grooving of the exterior surface of the plates is not confined to Maysville forms is indicated by a specimen (1914, Bulletin, Denison Univ., 17, pl. 4, fig. 4), found a short distance beneath the Fulton clay shale, containing the characteristic *Triarthrus becki*, in the upper part of the Point Pleasant beds of Orton, at the quarry located a quarter of a mile west of Point Pleasant, Ohio. In this specimen, the division lines between the plates are indicated by sharply impressed narrow grooves. The plates are hexagonal and concave; and distinctly impressed and relatively broad grooves extend from the angles of the plates toward the center, where they unite. The plates, apparently, must have been thin and practically there is no room for a concavity within the individual plates.

This structure evidently is quite distinct from that of *Pasceolus halli* Billings, the first described and first illustrated species of the genus, ranging from the Gamachian series, younger than the Richmond, into the Silurian strata of Anticosti. In this species, the exterior surface of all of the plates is distinctly convex. The plates probably are hollow, their lower surface is convex, and a short spine extends from the center of the base of each plate toward the center of the specimen. The short spine may be seen distinctly in specimens of *Pasceolus gregarius* Billings, a smaller sized species occurring in the Silurian strata of Anticosti after the disappearance of typical *Pasceolus halli*.

Apparently there are two groups of species included in *Pasceolus*, the group typified by *Pasceolus halli*, with convex plates, and the group typified by *Pasceolus darwini*, with concave plates and stellate grooves. The former usually are strongly calcareous. The latter occur in strongly argillaceous strata. The former occasionally preserve very delicate surface markings. In the latter no surface markings ever have been noticed in addition to the stellate grooves already described. This has raised the question whether it might not be possible that the so-called plates of the *darwini* group of *Pasceolus* in reality represent only the basal parts of the plates, the upper and lateral parts having been removed by weathering. In that case the stellate grooves would be features characterizing that part of the base of the plate which faces the hollow in the interior of the plate; and the grooves would converge toward the point of departure of the spine. I have not been able to either prove or disprove this hypothesis, with the specimens at my command.

Formerly, all the specimens of *Pasceolus* discovered in Cincinnatian strata were identified as *Pasceolus globosus*. This species was originally described by Billings from the Trenton, at Ottawa, Canada. *Pasceolus globosus* presents convex areas in the spaces evidently outlined by the vertical lateral margins of the plates. From this it is assumed that the exterior surfaces of the plates were convex, but I have seen no specimens in which these exterior surfaces actually were preserved. In other specimens, the depressions left by the inner surfaces of the plates are distinctly concave, but no indication of a short spine projecting from the center of the base of the plate toward the interior of the specimen is seen, nor is there any evidence of the presence of stellate grooves. Apparently, *Pasceolus globosus* is more closely related to *Pasceolus halli* than to the *Pasceolus darwini* group of species, and therefore, for the present, the name *Pasceolus globosus* is dropped from the list of Kentucky and Ohio species. Evidently, our present knowledge of the various so-called species of *Pasceolus* is in a very unsatisfactory condition.

3. **Dystactospongia madisonensis**, Foerste

(Plate III, Fig. 4)

1909. Dystactospongia madisonensis Foerste, Bull. Sci. Lab. Denison Univ., 14, p. 302, Plate 9, Figs. 1, 5. Also 1910, 16, p. 20

The specimen here figured, from a layer seven feet above the chief *Columnaria alveolata* horizon, near the base of the Saluda member of the Richmond, at Madison, Indiana, presents no evidence of the presence of oscula, or canals. This is true also of the specimen represented by figure 1 on plate 9, accompanying the original description of this species. In the Versailles specimen, represented by figure 5 on the same plate, oscula are readily discernible. Both the forms with and without oscula occur at the same horizon, and at the same localities, often intermingled. They have the same habits of growth, figure 5, on the plate cited above, being a part of a specimen having the same lobate growth as figure 1 on the same plate. The specimen, figure 1, from Madison, Indiana, is regarded as the type of the species, with which the specimen with oscula, figure 5, from Versailles, Indiana, is correlated, at least provisionally.

4. **Dystactospongia ? cavernosa, n. sp.**

(Plate III, Fig. 3)

Specimen 90 millimeters in length, 58 millimeters in width, and 36 millimeters in thickness, showing at the surface numerous

irregular cavities, averaging between two and three millimeters in diameter. These cavities are not the openings of tubes or canals and, therefore, do not correspond to oscula. Both laterally and toward the interior they are bounded by an intricate mass of fibrous tissue, separating the cavities from each other. The fibrous tissue between the cavities averages between one-fourth and three-fourths of a millimeter in thickness, although frequently equalling two millimeters at the angles between the cavities. This fibrous tissue is calcareous, and branches and anastomoses in a very irregular manner, so as to enclose smaller interspaces averaging between one-fourth and one-half of a millimeter in diameter, the smallest recognizable interspaces equalling scarcely one-fifth of a millimeter in diameter. Throughout the entire specimen the structure is very irregular. There is no central cavity, and no radiating structure extending from the central axis of the specimen toward the surface.

There are no large radiate oscula at the surface, as in *Dystactospongia insolens* Miller. The fibrous structure resembles that of *Heterospongia*, but there are no "branching and more or less tortuous canals, which begin near the center, where they are nearly vertical, and proceed toward all portions of the surface in a curved direction," as in *Heterospongia subramosa* (Geol. Minnesota, 3, pt. 1, 1895, pl. G, figs. 5, 6.). There is no large gastral cavity, there are no more or less numerous lobes at the surface, nor basal bundles of more or less parallel filaments for attachment, as in *Pattersonia difficilis* Miller. The structure of the specimen here described, therefore, seems to be different from that of any form hitherto described from the vicinity of Cincinnati, and a new generic designation may eventually prove desirable.

The original label has been lost, but the specimen is known to have been obtained at Cincinnati, Ohio, and probably was found in the middle part of the Maysville group.

5. **Leptopoterion faberi,** Miller

(Plate II, Fig. 2A, 2B)

1889. Leptopoterion mammiferum Ulrich, Am. Geol., 3, pp. 239
1889. Chirospongia faberi Miller, N. A. Geol. Pal., p. 156, Fig. 99

The type of *Leptopoterion mammiferum* was found in the Corryville division of the Maysville, in the quarries on Roh's hill, at Cincinnati, Ohio, by Prof. Charles Schuchert, and was stated in the original description to be in the Ulrich collection, but it is not listed

among the types in the Ulrich collection in the U. S. National Museum, at Washington.

The type of *Chirospongia faberi* is preserved in the Faber collection at Chicago University; it is numbered 8827 and is also listed as coming from Cincinnati, Ohio. In the original description it is stated to be associated with *Pattersonia* about 350 feet above low water in the Ohio river. The type of *Chirospongia faberi* is here figured. It gives but little information regarding the structure of the sponge wall. Numerous, relatively thick, short striæ, regarded as spicules, from half to three-quarters of a millimeter long, traverse the surface longitudinally. These are arranged in quincuncial order, so as to produce the effect not only of longitudinal striation, but also of a sort of oblique striation. Locally, the thick longitudinal striations appear to be interwoven with much finer, apparently short, cross striations. While some of the latter striations make angles of about 60 degrees with the coarser longitudinal striations, this angle is not known to be constant, and the exact form of the spicules, whether three-rayed or six-rayed, can not be demonstrated from this type.

By Ulrich, the surface of *Leptopoterion mammiferum* was regarded as suggesting a net-work of overlapping hexactinellid spicules having the six rays spread in one plane, but the evidence is not conclusive.

6. **Protaraea vetusta,** Hall

(Plate II, Fig. 3)

1847. Porites ? vetusta Hall, Pal. New York, 1, p. 71, pl. 25, Figs. 5a, b.
1851. Protaraea vetusta Edwards and Haime, Ann. Sci. Nat., 3rd ser. Zool., 16 p. 47.
1899. Protarea vetusta Lambe, Cont. Canadian Pal. Geol. Surv. Canada, 4, pt. 1, p. 90, Plate 5, Figs. 8, 8a

The type of *Protaraea vetusta,* numbered 642, is preserved in the American Museum of Natural History, in New York City, and is labelled as coming from the Trenton at Watertown, New York. The number of corallites is about 5 in a length of 5 millimeters, sometimes equalling only about four and a half corallites in this distance. The surface of the type is badly weathered and the septa can not be traced beyond the immediate vicinity of the walls, though probably reaching half way toward the center of the calyces in well preserved specimens. The vertical tubules in the spaces between the corallites are fairly distinct under a lens. The specimen

consists apparently of a succession of lamellae, each from 1 to 2 millimeters in thickness, locally more or less free from each other.

Protaraea vetusta occurs in the cystid beds in the lower part of the Hull formation, in the Trenton, a short distance above water level on the eastern side of Nepean point at Ottawa, in Canada.

Lambe figures the tubules between the corallites in *Protaraea vetusta*, and Whiteaves, in his description of *Protaraea magna* clearly describes them. No tubules have been noticed in the spaces between the corallites of the Richmond species long correlated with *Protaraea vetusta*, but for which the name *Protaraea richmondensis* was proposed recently. In fact, I have long doubted whether the Richmond form even belonged to the same genus as the Trenton *Protaraea vetusta*. Both the calyces and the interspaces of the Richmond form are strongly papillose, and clearly defined septa are rare except in a few gerontic specimens.

The genotype of *Protaraea* is the Richmond, and not the Trenton form, as may be seen by consulting figures 6 and 6a on plate 14 accompanying the original description of the genus. (1851, Edwards and Haime, Mon. d. Polyp. Foss. d. Terr. Pal.)

7. **Calapoecia cribriformis**, Nicholson

(Plate III, Fig. 5)

1874. Columnopora cribriformis Nicholson, Geol. Mag., dec. 2, 1, p. 253

1875. Columnopora cribriformis Nicholson, Geol. Surv. Ohio, Pal. 2, p. 187, Plate 22, Figs. 8, 8a, 8b

1879. Columnopora cribriformis Nicholson, Tab. Corals Pal. Period, p. 164, Plate 7, Figs. 2-2d

The first figured specimen of this species (figure 8 in the Paleontology of Ohio) at present forms No. 216 in the James collection in the Museum at Chicago University, and a new illustration of this type is offered in the present bulletin. The same specimen was used also for figure 2 in Nicholson's work on the Tabulate Corals. The calyces of the corallites have circular, rather than polygonal outlines. According to Nicholson the origin of this specimen was: "In the Cincinnati Group (Hudson River Formation), near Cincinnati, Ohio (collected by Mr. U. P. James)." The expression "near Cincinnati," however, must be interpreted in a liberal sense, since the specimen almost certainly was obtained from the Richmond group of some part of Ohio, Indiana, or Kentucky, where it ranges from the Liberty to the Whitewater and Saluda members. In these

Cincinnatian areas, the corallites occasionally attain a diameter of 3 millimeters, but more commonly average between 2 and 2.3 millimeters. The tabulae rarely are well preserved; sometimes only the marginal parts, where attached to the walls of the corallites, are retained, but usually the tabulae have been entirely removed by weathering. About 7 to 10 tabulae occur in a length of 5 millimeters, occasionally increasing to 12 in this distance. The denticulate projections along the crest of the septal ridges rarely are well preserved. Judging from the small size of the figured type it is probable that it was obtained somewhere in Clinton or neighboring counties, in Ohio, where specimens are rare,and usually quite small.

The Canadian cotypes of *Columnopora cribriformis*, obtained, according to Nicholson "In the Hudson River Group, River Credit, Ontario (collected by Dr. G. J. Hinde)," were found at Streetsville, about 17 miles west of the center of Toronto. From Streetsville Junction a road leads northeast to the Credit river, and *Calapoecia* occurs west of the bridge, along the northern side of the river. The horizon corresponds approximately to the Whitewater as exposed in Ohio and Indiana. The Canadian cotypes from the Credit river were destroyed by the fire which burned up the Museum of the University of Toronto, years ago.

Both the Ohio and Credit river cotypes of *Columnopora cribriformis* evidently are specifically identical with *Calapoecia huronensis*, described by Billings (1865, Canadian Naturalist, volume 2, page 426) from the "Hudson River formation, Cape Smyth, Lake Huron." Cape Smith forms the most eastern part of Manitoulin island. The Richmond exposures occur at the Clay Cliff, about 4 miles south of the extremity of the cape. Here, as well as at numerous other localities on Manitoulin island, *Calapoecia huronensis* occurs both in strata corresponding to the Waynesville member as well as in those correlated with the Whitewater member of the Richmond.

Houghtonia huronica, described by Rominger (1876, Geol. Surv. Michigan, vol. 3, pt. 2, p. 18) from the "Hudson River group of Drummond's island, associated with *Columnaria stellata,*" also is identical with *Calapoecia huronensis.* On Drummond island the Richmond exposures form the extreme northern margin of the island, extending in an east and west direction for about 5 miles. The specimens described by Rominger probably were obtained from strata corresponding to the Coral zone, in the lower part of the

Whitewater division of the Richmond, as identified on Manitoulin island.

Lambe (1899, Canadian Pal. Corals, pt. 1, p. 43) regards the Richmond specimens of *Calapoecia* from all of these localities as identical with *Calapoecia canadensis*, a form described by Billings (1865, Canadian Naturalist, vol. 2, p. 426) from the "Black River limestone near Ottawa." Here it was collected at the Paquette Rapids, on the Ottawa river. The Black River specimens of *Calapoecia* appear to have thinner corallite walls, the arrangement of the pores along horizontal lines appears more conspicuous, and the denticulations along the septal ridges appear more conspicuous, but Lambe is probably correct in failing to find any constant differences, of sufficient importance to be regarded as specific, between the Richmond and Black River forms. If it be desired to distinguish the Richmond forms from the latter, the term *Calapoecia huronensis* must be employed.

8. **Tetradium ontario,** Hall

1884. Tetradium ontario Hall, 35th Rep. New York State Mus. Nat. Hist., Plate 16, Fig. 9. (Figured but not described)

1888. Tetradium approximatum Ulrich, Amer. Geol., 1, p. 183 (Nomen nudum)

1915. Tetradium approximatum Bassler, Bibl. Index Am. Ord. and Sil. Fossils, Bull. 92, 2, U. S. Nat. Mus., p. 1264 (Numerous references to literature and published illustrations)

An excellent illustration of a cross section of *Tetradium ontario*, showing the form of the corallites in a very satisfactory manner, was published by Hall on a plate intended to illustrate the value of translucent sections in the study of corals. The origin of the specimen is cited as "Clinton group, shore of lake Ontario," but the specimen was an erratic one, colored reddish, derived from the basal part of the red Queenston clay shales north of the western end of Lake Ontario. Specimens of *Tetradium ontario* occur in situ at this horizon at the exposures along the small creek northeast of Oakville, about 20 miles southwest of Toronto, in the province of Ontario, in Canada, and it is evidently from this province that the type was obtained. The horizon at Oakville corresponds approximately to the base of the Coral zone at Streetsville, on the river Credit, about 10 miles directly north of Oakville. This horizon forms the base of those Canadian strata at present correlated with

the Whitewater member of the Richmond in Indiana and Ohio. The species ranges, however, from the lower part of the Waynesville member to the top of the Whitewater member, on Manitoulin island, and it occurs also in the fossiliferous layers near the middle of the Queenston clay shales, near Meaford, in Ontario. These Queenston shales are regarded as occupying the same time interval as the Whitewater member of the Richmond.

Ulrich prepared a monograph on the various species of *Tetradium* but the plates were destroyed by fire and the monograph was never published. The only remnant of this monograph is the inclusion of the name *Tetradium approximatum* in his list of fossils from the Cincinnati Group, and the reference of this species to his beds XIII and XIV. His beds XIII include the Arnheim, Waynesville, and Liberty members of the Richmond, while beds XIV included the Whitewater and Elkhorn members. Evidently Ulrich regarded *Tetradium approximatum* as ranging through a considerable part, if not all, of the Richmond.

In my own collecting, in the Richmond of Cincinnatian areas, I have found *Tetradium* to range from the base of the Clarksville division of the Waynesville member of the Richmond to the top of the Richmond.

The term *Tetradium approximatum* evidently applies to the common Richmond form, which has a wide geographical range, both in the United States and in Canada. It can not be said, however, to have had any validity prior to the publication of Bassler's Index. It seems unfortunate that Hall's casual illustration of an erratic specimen should give priority to the term *Tetradium ontario*, but this actually is the case.

Dania huronica, described from Drummond island by Edwards and Haime (Mon. d. Polyp. Foss. Terr. Pal., 1851, p. 275, pl. 18, fig. 2, 2a. 2b) must be regarded for the present as a problematical species. Although usually assumed as of Niagaran age, the corallites are described as scarcely attaining a diameter of one millimeter even in the case of the largest corallites. No Niagaran coral is known from Drummond island with corallites of such small dimensions. Specimens of *Tetradium* however occur in the Richmond along the northern shore of the island, and occasionally the septa are rather distant and occur approximately at the same height across 6 to 20 of the exposed adjacent corallites.

9. **Dermatostroma papillatum,** James

(Plate I, Fig. 3)

1878. Stromatopora papillata James, Paleontologist, 1, p. 1
1910. Dermatostroma papillatum Parks, Univ. Toronto Studies, Geol. Series, 7, p. 30, Plate 23, Figs. 8-10

Specimens bearing the label, *Stromatopora papillata,* and numbered 1553, occur in the James collection, at Chicago University. They are labelled as coming from Ohio and Indiana. In two of these specimens, the growth incrusts valves of *Strophomena planumbona,* apparently from the Waynesville bed. Six or seven papillae occur in a length of 2 millimeters, measuring in the direction of the radiating striae of the *Strophomena.* In a third specimen growing upon *Strophomena sulcata,* presumably from the Waynesville or Liberty, seven papillae occur in a length of 2 millimeters, parallel to the radiating striae of the shell. Three additional specimens, bearing the same number, are regarded as belonging to *Dermatostroma glyptum* (Foerste), a species occurring in the Whitewater division of the Richmond.

The specimen illustrated in this bulletin was collected from the Clarksville division of the Waynesville member of the Richmond at Clarksville, Ohio, and is attached to a valve of *Byssonychia.* The granules tend to be arranged in rows parallel to the radiating plications of the *Byssonychia,* but toward the margin of the shell, where the plications are quite broad, the linear arrangement of the papillae is much less in evidence, indicating that this arrangement is dependent upon the character of the surface markings of the shell upon which the *Dermatostroma* grows. From 5 to 6 papillae occupy a length of 2 millimeters.

10. **Dermatostroma scabrum,** James

(Plate I, Fig. 4)

1879. Stromatopora scabra James, Paleontologist, 3, p. 18
1910. Dermatostroma scabrum Parks, Univ. Toronto Studies, Geol. Series, 7, p. 31, Plate 24, Figs. 1-3.

The cotypes of *Stromatopora scabra* were collected by Mr. W. H. Bean near Lebanon, Ohio; one from an horizon 10 to 20 feet below the large *Platystrophia ponderosa* (Mount Auburn) bed, and the other at a higher horizon. These horizons correspond evidently to the upper part of the Corryville member of the Maysville and to the Arnheim or Waynesville members of the Richmond respectively.

Dr. George M. Austin collected a typical specimen in the Waynesville member at Clarksville, Ohio (illustrated in this bulletin). Many of the monticules are abruptly conical, and fully one millimeter high. They are arranged more or less in series along the crests of the radiating plications of a *Byssonychia*, about 4 or 5 monticules occurring in a length of 10 millimeters. The papillæ also are arranged in series parallel to the plications, about 6 or 7 in a length of 2 millimeters. The incrustations of *Dermatostroma scabrum* usually are thicker than those of *Dermatostroma papillatum*. This raises the question whether *Dermatostroma scabrum* may not be merely the more mature form of *Dermatostroma papillatum*.

When attached to smooth surfaces, the monticules do not show any tendency toward arrangement in rows. There is no doubt, however, about the influence of the plications or narrow ridges of the supporting shells upon the arrangement of these monticules.

11. **Dermatostroma glyptum,** Foerste

(Plate I, Fig. 2)

1910. Labechia corrugata glypta Foerste, Bull. Sci. Lab. Denison Univ., 16, p. p. 87. (July 15)

1910. Dermatostroma corrugatum Parks, Univ. Toronto Studies, Geol. Series, 7, p. 33, Plate 24, Fig. 7. (October)

The type specimen, here figured, belongs to Dr. George M. Austin, and was found by him on Dutch creek, northwest of Wilmington, Ohio, in the upper part of the Whitewater member of the Richmond.

Papillæ coarse, varying greatly in number in different parts of the same specimen; usually from 3 to 4 in a length of 2 millimeters, but locally increasing to 6 in the same distance. In addition to papillæ there are ridge-like elevations, varying greatly in length. The shorter of these ridges consist of a uniserial line of papillæ, or of a more or less irregular agglomeration of papillæ, of larger height and width than the remainder, so united as to form short ridges or irregular elevations, and between the latter occur the ordinary papillæ. In addition to the shorter ridges, there are also longer ridges extending in a very irregular, vermiform manner across the surface, the ridges often crossing each other. These longer ridges occasionally have the appearance of being the limiting edges of separate individuals of the same species which have become attached to the

same host, and which interfere more or less at their points of contact. The specimens usually are incrusting on shells or other fossils. The type, by far the largest specimen known at present, is attached to the exterior of a large *Cameroceras*, 60 millimeters wide and 110 millimeters long. The thickness of the incrustation varies from less than a millimeter to fully 3 millimeters. The short ridges and irregular agglomerations noted above are regarded as the most characteristic feature of this species when typically developed, but in younger specimens these are not conspicuous and the coarser size of the papillæ is depended upon to distinguish it from *Dermatostroma papillatum* and *D. scabrum*. All specimens of *Dermatostroma glyptum* found so far occurred in the Whitewater member of the Richmond.

12. **Stromatocerium granulosum**, James

(*Plate I, Fig. 1*)

1865. Stenopora huronensis Billings (part), Geol. Surv. Canada, Pal. Foss., 1, p. 185

1875. Alveolites granulosus James, Cat. Foss. Cincinnati Group, p. 2

1883. Tetradium huronense Foord (part), Contr. Canadian Cambro-Sil. Micropal, p. 25, Plate 7, Figs. 1, 1a

1885. Labechia ohioensis Nicholson, Mon. British Strom., p. 32, Plate 1, Figs. 1, 2

1910. Stromatocerium huronense Parks, Univ. Toronto Studies, Geol. Series, No. 7, p. 20, Plate 22, Figs. 4-10, Plate 23, Fig. 5

A specimen of *Tetradium* encrusted with a thick growth of *Stromatocerium* served as the type of *Stenopora huronensis*, and the specimen was described by Billings as though the papillæ on the surface of the *Stromatocerium* were the terminations of the tubular corallites of the *Tetradium*. However, almost the entire description evidently is based upon the *Stromatocerium*. Foord redescribed the same specimen under the name *Tetradium huronense*. It is evident that he also regarded the surface features of the *Stromatocerium* as surface features of the *Tetradium*, and while he recognized the structure of the tubules at the center of the specimen as that of *Tetradium*, he did not differentiate that of the encrusting organism as *Stromatocerium*. In the meantime, however, James had described the same species from another locality, without any confusion of *Stromatocerium* and *Tetradium*, as *Alveolites granulosus*. The specimen described by Billings and Foord was obtained from the lower part of those strata on Manitoulin island, at Cape Smith, which correspond approximately with the Whitewater member

of the Richmond. The specimen described by James was obtained in the *Orthoceras fosteri* zone, at the base of the Clarksville division of the Waynesville member, at Clarksville, Ohio.

The type of *Alveolites granulosa*, figured in this Bulletin, is preserved in the James collection, at Chicago University, and is numbered 2250. It is not desired in this publication to revive the name used by James, in preference to *Stromatocerium huronense*, now generally accepted, but merely to offer a good illustration of the James type.

The interior structure of *Alveolites granulosa* is well presented by Prof. W. A. Parks (loc. cit. pl. 22, figs. 6, 10), and he figures also a second specimen from identically the same locality and horizon as this type (pl. 22, figs. 5, 8, 9). The specimen figured by Nicholson under the name *Labechia ohioensis* was obtained at Waynesville, Ohio, probably from the same part of the Waynesville member as the type of *Alveolites granulosa*. The structure of this species, therefore, may be said to be well known.

Under an ordinary magnifier, the type of *Alveolites granulosa* presents the appearance of a succession of papillose layers resting upon variable thicknesses of intermediate vesiculose tissue penetrated by vertical pillars. Frequently, on the weathered lateral surface of the specimen, the vertical pillars appear laminar, rather than filiform, and the vesiculose tissue presents the appearance of transverse tabulæ crossing the interior of narrow corallites. That this appearance is deceptive is shown by the transverse sections. The pillars usually grow in fascicles, each fascicle giving rise at the surface to a distinct mamelon, the pillars of the same fascicle spreading upward and outward from the center of the fascicle toward the surface of one of the mamellate elevations. Since the mamellate elevations of successive plates are not necessarily directly over each other, the spreading of these fascicles of vertical lamellæ at times is very irregular, those of different layers being inclined at different angles. In the original description by James this structure was noted in the following terms: "In some cases groups of corallites seem to radiate from different points or axes, and weathered sections show them as growing at various angles in the mass, shorter and longer and curving in different directions." It should be noted that this fasciculate structure is shown by vertical weathered sections, and that no reference is made here to the radiate arrangement

sometimes shown by the papillæ on the *surface* of the mamellate elevations.

13. **Stromatocerium montiferum,** Ulrich

(Plate II. Fig. 1)

1886. Labechia montifera Ulrich, Contr. to Amer. Pal., 1, p. 33, Fig. also Figs. 9 and 9a on plate 2, from a different specimen and horizon

The type of *Labechia montifera* was obtained at Madison, Indiana. It consists of a thin incrustation of *Stromatocerium*, locally 2 millimeters thick between the mamelons, elsewhere even thinner, growing upon a specimen of *Spyroceras hammelli* Foerste. This species of *Spyroceras* is not rare in the upper part of the Saluda at Madison, especially in the Hitz bed, and it occurs also at the same horizon at the Dog Falls, west of Hanover. It occurs also in lower parts of the Saluda member of the Richmond at various localities in southeastern Indiana, and probably ranges through most of the Richmond, since typical specimens are not rare in the Waynesville member of the Richmond on Manitoulin island, in Lake Huron. It may be regarded as practically certain, however, that the type of *Labechia montifera* was obtained in the upper part of the Saluda at Madison, since thin growths of *Stromatocerium* often occur on the specimens of *Spyroceras* found there, and this is the only horizon at Madison at which *Spyroceras* has been found.

The surface of the type specimen is covered with papillæ, usually from 5 to 6 in a length of 2 millimeters, where the papillæ are best preserved, but varying locally from as low as 4 to as high as 8 in the same length. The number of mamelons varies from 5 in a length of 20 millimeters to about 4 in the same length. Some parts of the incrustation are fully 2 millimeters thick in the spaces between the mamelons. Along one side of the specimen the mamelons are low and rather indistinct, but elsewhere they are sharply defined.

The type specimen bears no evidence of having been sectioned, but the original description is accompanied by figures of a specimen from Waynesville, Ohio, which present vertical and transverse sections of the latter.

These sections indicate clearly that the Waynesville specimen, at least, can not be differentiated from typical *Stromatocerium huronense*. The occurrence of thin films of *Stromatocerium* on *Spyroceras* at Madison does not in itself indicate a distinct species,

since much thicker growths occur there also in the same horizon, some of them several inches in thickness. In fact, *Labechia montifera* appears to be identical with *Stromatocerium huronense*. At least, if distinct, the distinguishing characteristics have not yet been noted.

The type of *Labechia montifera* is in the possession of George K. Greene, of New Albany, Indiana.

14. **Stromatocerium indianense,** James

1892. Stromatopora indianensis James, Jour. Cincinnati Soc. Nat. Hist., 15, p. 92

The type of *Stromatopora indianensis* was a characteristic specimen of *Stromatocerium huronense* from the *Beatricea nodulosa* horizon in the Elkhorn member of the Richmond, at Longwood, five and a half miles west of Connersville. At this locality, *Stromatocerium,* associated with *Tetradium,* is common about 70 feet below the exposures of the Laurel limestone division of the Silurian. On Elkhorn creek, three miles southeast of Richmond, Indiana, *Stromatocerium* occurs immediately below the Brassfield limestone member of the Silurian, also 11 feet lower, and *Beatricea* is found both at 14 and at 29 feet below the Brassfield. In fact, both *Stromatocerium* and *Beatricea* range throughout the Elkhorn member, although usually confined at each locality to only one or two horizons.

The type of *Stromatocerium indianense* had the characteristic large and prominent mamellate elevations of the Richmond species, *Stromatocerium huronense.* It was a massive specimen 8 inches long, 6 inches wide, and 5 inches high. It can no longer be found among the specimens preserved in the U. S. National Museum, but there is no doubt as to identity of the species.

15. **Stromatocerium huronense australe,** Parks

1910. Stromatocerium huronense australe Parks, Univ. Toronto Studies, Geol. Series, No. 7, p. 24, Plate 22, Fig. 11

Stromatocerium huronense australe was described from a series of Kentucky Richmond forms belonging to the Ulrich collection, deposited in the U. S. National Museum, at Washington; but the only figured specimen, also from the Ulrich collection, was obtained in the Leipers division of the Maysville, near Nashville, in Tennessee. Ignoring the Richmond forms, Bassler, in his Bibliographic Index

(Bull. 92, U. S. Nat. Mus. Vol. 2, p. 1213, 1915) lists the Leipers form as the holotype.

The Richmond specimens mentioned in the original description were obtained at three localities: Upper Richmond, near Lebanon, Ky.; top of Cincinnati Group, 18 miles east of Louisville, Ky.; and Upper Richmond, eastern part of Jefferson county, Kentucky.

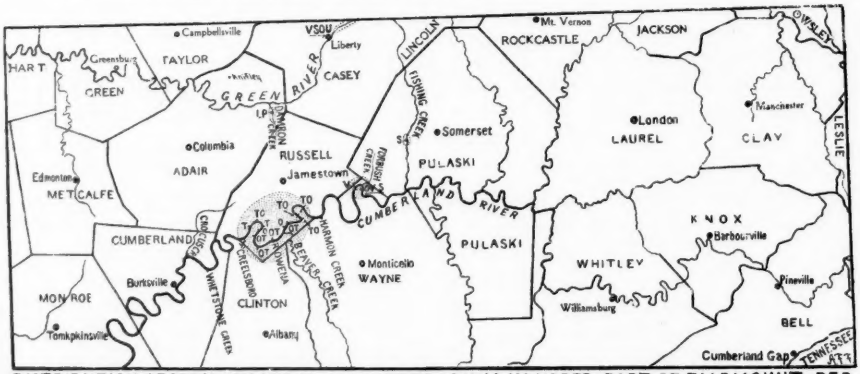
In the area west of the Cincinnati geanticline in Kentucky, *Stromatocerium* is known at only two horizons in the Richmond. One of these is at the top of the Saluda member, but below the Hitz layer, when the latter is present. The second horizon includes the great coral reef at the base of the Liberty member, and extends from a short distance below this reef to a short distance above the latter. There is no reason why *Stromatocerium* should not occur also in the Coral reef in the lower part of the Waynesville member, since it is usually associated with one or more species of the massive corals, and is known to occur as low as the base of the middle or Clarksville division of the Waynesville at various localities in Ohio. In south-central Kentucky, at various localities in Clark, Madison, and Garrard counties, *Stromatocerium* is found in the upper half of the Arnheim, above the *Dinorthis carleyi* horizon; and at Wyoming, in the southern edge of Fleming county, it occurs at the base of the *Platystrophia ponderosa* horizon which there appears to correspond approximately to the position of the Mount Auburn member of the Maysville, if this member extends that far southeastward. As a matter of fact, however, *Stromatocerium* is unknown at present from any of these lower horizons in any part of the area west of the Cincinnati geanticline, in Kentucky.

I am unable to distinguish any of the Richmond specimens of *Stromatocerium* found in any part of the area west of the Cincinnati geanticline, between Lebanon and Louisville, from the typical forms of *Stromatocerium huronense*, as found at the type locality, the Clay Cliff, south of Cape Smith, on the eastern shore of Manitoulin island. Even at the type locality there is great variation in the prominence and angularity of the mamelons, and in the distance between the latter. That corresponding differences are seen in the Kentucky specimens is indicated by the reference of specimen No 39488, from the Upper Richmond a mile and a half west of Lebanon, Kentucky, to the typical form of *Stromatocerium huronense* (Parks, loc. cit. p.24).

I have often wondered, however, whether it might be possible, on minute examination, to distinguish the Leipers form of *Stromato-*

cerium from that characteristic of the Richmond. It was the Leipers form, from the vicinity of Nashville, which was figured by Parks as an illustration of his *Stromatocerium huronense australe*, and this is the specimen listed by Bassler as the holotype.

In Kentucky, *Stromatocerium* is known from the Leipers division of the Maysville only from the Cumberland river exposures, between Harmon creek and Creelsboro, in the southern part of Russell county. Here it is associated with *Tetradium fibratum*, *Escharopora hilli*, *Strophomena maysvillensis*, *Orthorhynchula linneyi*, and *Cyrtoceras vallandinghami*, a typical Leipers fauna. This Leipers fauna extends northeastward into Marion, Boyle, Garrard, and Madison counties, but farther northward apparently merges into the upper part of the Fairmount member of the Maysville, and only a few of the characteristic species reach the Ohio river.



DISTRIBUTION OF STROMATOCERIUM AND TETRADIUM IN UPPER PART OF FAIRMOUNT BED. COLUMNARIA VACUA, STREPTELASMA, STROMATOCERIUM, AND BEATRICEA UNDULATA IN RICHMOND.

In the accompanying sketch map, indicating these exposures of the Leipers member of the Maysville, along the Cumberland river in Kentucky, at which *Stromatocerium* was found, several interesting Richmond localities also are noted. In the northern part of Wayne county, opposite the mouth of Forbush creek, *Stromatocerium* was found associated with *Columnaria vacua* and *Streptelasma rusticum*. The *Streptelasma* was found also on Fishing creek, in Pulaski county, along a road leading west from Somerset.

Stromatocerium occurs also north of the road from Liberty to Hustonville, on the northern side of Green river, nearly 2 miles

northeast of Liberty, in Casey county. Here the following interesting section is shown:

New Albany Black shale	1 ft.
Greenish clay over phosphatic sandy layer, regarded as the base of the Devonian exposures here	6 in.
Argillaceous rock, cracking into rubble, unfossiliferous, regarded as equivalent to the Saluda member of the Richmond	27 ft. 6 in.
Calcareous strata with *Tetradium* abundant and massive, and with a few specimens of *Stromatocerium*	1 ft. 2 in.
Blue limestone with *Platystrophia* and *Hebertella sinuata*	10 in.
Calcareous strata with *Columnaria vacua* and *Beatricea undulata*	1 ft.
(The overlying fossiliferous strata are regarded as equivalent to the coral zones in the lower part of the Liberty member in Marion county, and farther northward.)	
Argillaceous strata, unfossiliferous, regarded as approximately equivalent to the Waynesville member of the Richmond, the base of this member being not exposed here	30 ft.

A small exposure of the Arnheim member of the Richmond, containing *Leptaena richmondensis precursor*, is indicated on Damron creek, in the northeastern part of Adair county. *Platystrophia ponderosa* occurs at a lower horizon in strata regarded as equivalent to the upper part of the Maysville. The *Leptaena* occurs within 12 inches of the base of the Devonian limestone which here intervenes between the top of the Arnheim and the base of the New Albany Black Shale, so that only the basal part of the Richmond is preserved here.

16. **Lingula covingtonensis,** Hall and Whitfield

(*Plate III, Fig. 7*)

1875. Lingula covingtonensis Hall and Whitfield, Pal. Ohio, 2, p. 67, Plate 1, Fig. 1
1910. Lingula covingtonensis Foerste, Bull. Sci. Lab. Denison Univ., 16, p. 22, Plate 5, Fig. 5

The type of *Lingula covingtonensis,* numbered 139 in the James collection at Chicago University, was figured, enlarged, in the Bulletin of Denison University, cited above. The type presents the interior of the upper valve, partly exfoliated. It is labelled as coming from Kentucky, opposite Cincinnati, and was obtained in the upper part of the Cynthiana formation, in strata described by Orton as the River Quarry beds.

These River quarry beds are not identical with the Point Pleasant beds of Orton. At the time Orton defined his Point Pleasant beds,

the *Triarthrus becki* horizon, immediately overlying the River quarry beds, opposite Cincinnati, was well known and the same horizon, is typically exposed at Point Pleasant. Below this *Triarthrus becki* horizon, both at Cincinnati and at Point Pleasant, occurred coarse-grained layers of limestone containing apparently the same species of *Trinucleus concentricus* as that occurring in the strata overlying the *Triarthrus becki* horizon. At Point Pleasant there were hill quarry beds as well as river quarry beds. The former included chiefly the strata extending between 75 and 115 feet above the water level, and the latter extended along the immediate edge of the river and were worked chiefly at low water, although locally rising to about 15 feet above the water's edge. This explains Orton's statements in his original definition of the Point Pleasant beds (Ohio Geol. 1, 1872, p. 370):

"—— the river quarries in the central portions of Clermont county, which lie a dozen miles south of Cincinnati, disclose rocks that underlie by at least 50 feet the lowest beds at Cincinnati. The locality at which these lowest rocks of the State present the best exposures and clearest section is Point Pleasant, and this division can accordingly be named the *Point Pleasant beds.* Its boundaries have been already assigned by implication; these beds beginning at low water mark at Cincinnati, and descending until they include the lowest rocks exposed in the State."

17. **Lingula vanhornei,** Miller

(Plate III, Fig. 6, Plate IV, Fig. 5A, B)

1875. Lingula vanhornei Miller, Cincinnati Quart. Jour. Sci., 2, p. 9, Fig. 1

The type of *Lingula vanhornei,* numbered 8865, in the Faber collection at Chicago University, is an entire shell, partly exfoliated. The illustration accompanying the original description represents the pedicel valve, and this valve is illustrated also in the present bulletin.

The species appears more closely related to *Lingula procteri* Ulrich, as illustrated by Hall and Clarke (Pal. New York, 8, pt. 1, pl. 1, figs. 5, 6), than to the group of species typified by *Lingula cincinnatiensis,* of which *Lingula iowensis* is a member. In *Lingula iowensis,* the brachial valve is characterized by a bold, sharp median septum, terminating abruptly a considerable distance anterior to the concrete laterals, of Hall and Clarke. No such conspicuous

median septum is indicated by the type of *Lingula vanhornei.* Here the concrete laterals are rather weakly defined, and their anterior margin extends to a distance of nearly 11 millimeters from the beak, the entire length of this brachial valve being 17 millimeters. Between these concrete laterals there is an ill-defined linear space, about half a millimeter in width anteriorly, obscurely elevated at the lateral margins, and this linear space extends anterior to the concrete laterals as far as the anterior part of the vascular trunks, of Hall and Clarke. These vascular trunks are within 1.5 mm. from the margin of the shell at a distance of 11 mm. from the beak, and curve around anteriorly so as to reach within 1.7 mm. of the front margin of the shell. In their curvature, these vascular trunks of *Lingula vanhornei* closely resemble those of *Lingula elderi,* as figured by Hall and Clarke. Faint traces of vascular branches extend from the vascular trunks toward the antero-lateral and anterior margins of the shell, as in *Lingula elderi,* but there are no traces of vascular branches extending from the vascular trunks toward the concrete laterals.

The general shape of the muscular area of the pedicel valve of *Lingula vanhornei* also is similar to that of *Lingula procteri.* In general this shape may be defined as broadly cuneate with a very divergent V-shaped anterior margin along which the interior of the shell is moderately thickened and from which radiate vascular branches. The narrow, almost linear area, between the concrete laterals forming the major part of this muscular area, is not clearly defined. The vascular trunks of the pedicel valve pursue essentially the same directions as those of the brachial valve, and from these trunks the vascular branches may be traced toward the antero-lateral and anterior margins of the shell, but the vascular branches between these vascular trunks and the anterior margin of the concrete laterals appear to radiate from the anterior margin of the latter toward the vascular trunks, of Hall and Clarke, and do not appear to have their origin in these trunks and to extend from the trunks toward the concrete laterals, as in the figures presented by these authors in the case of *Lingula elderi.*

The length of the type is 18 mm. the beak of the pedicel valve extends almost a millimeter anterior to that of the brachial valve. The width of the shell is 11 mm. The thickness from valve to valve is 4.5 mm. The outline is oval oblong. The type was found at Versailles, Indiana, and probably came from the Waynesville member

of the Richmond group. The species however makes its appearance already in the Arnheim. About a mile south of Milton, Kentucky, along the road to Bedford, a specimen referred to this species was found 11 feet above the *Dinorthis carleyi* horizon, and 13 feet below the lowest strata containing *Strophomena planumbona* and *Dalmanella jugosa*.

18. **Lingula brookvillensis,** n. sp.

(*Plate IV, Figs. 6 A, B*)

A medium sized *Lingula*, found at Boundary Hill, about two miles west of Brookville, in Indiana, closely resembles *Lingula cincinnatiensis* Hall and Whitfield in its internal features. *Lingula cincinnatiensis* is characteristic of the Fairmount division of the Maysville group, in Ohio, Indiana, and Kentucky, and a form not to be distinguished from this species occurs in the Rogers Gap member of the Cynthiana group, about one mile north of Rogers gap, in Kentucky. *Lingula rectilateralis* Emmons, from the Utica and Trenton of New York, and *Lingula iowensis* Owen from the Trenton of Wisconsin, Iowa, Minnesota, Illinois, and Manitoba, are closely related to, and almost identical with *Lingula cincinnatiensis*. All of these species belong to the group, typified by *Lingula quadrata* Eichwald, for which the term *Pseudolingula* was proposed by Mickwitz, in 1909. As defined by Schuchert *Pseudolingula* is characterized by a ventral pedicel groove and a pair of umbonal muscles, features ordinarily not likely to be exposed.

From the species mentioned above, the Brookville specimen differs conspicuously in its smaller size. The length of the brachial valve is 15.5 mm., the width is 9.5 mm., and the thickness from valve to valve is about 3.4 millimeters. The beak of the pedicel valve extended at least half a millimeter beyond that of the brachial valve. The sides of the shell are subparallel for a length of about 7 mm., and then curve posteriorly into the postero-lateral margin, which forms an angle of about 140 or 145 degrees with the lateral margin. The beak of the brachial valve is rather narrowly rounded. The anterior margin of the shell is moderately convex, rounding rather strongly into the lateral margins, producing a quadrangular outline very similar to that of *Lingula cincinnatiensis*, but distinctly more elongated.

Along the middle parts of the shell, between two imaginary lines extending from the beak to the antero-lateral angles, the valves

are moderately convex. From these lines, the surface slopes rather strongly toward the postero-lateral angles, being more or less concave near the margin of this part of the shell. Along the median part of the brachial valve the shell is faintly elevated anteriorly, the elevation being separated from the antero-lateral parts of the valve by broad, shallow, almost obsolete depressions, also following directions radiating from the beak; these depressions are about 4 millimeters apart at the anterior margin of the valve. There is a slight tendency toward a median elevation also on the pedicel valve, but this elevation has a width of scarcely 2 millimeters. The surface of the shell is marked by fine concentric lines, often 15 in a length of one millimeter. Fine radiating lines traverse the shell, especially along the moderately convex median parts, included between the imaginary lines leading from the beak to the antero-lateral angles; within this space the radiating lines usually number about 8 in a width of one millimeter.

The interior of the brachial valve is characterized by a long median septum, extending nearly 11 millimeters forward from the beak, and attaining its greatest width and elevation within one millimeter of the end, where its width is 1.2 mm., and its elevation 0.8 mm. Two narrowly cuneate very shallow depressions extend forward for a distance of 7 mm. from the beak, one on each side of the septum, attaining a width of about 1.2 mm. at their anterior ends. At their anterior ends these cuneate depressions are limited quite distinctly by moderately elevated crescentic elevations extending laterally from the median septum for a greater distance than the cuneate depressions themselves. The crescentic elevations and the narrowly cuneate depressions correspond to the central scars and the concrete laterals of Hall and Clarke, as figured by them in case of *Lingula iowensis* (Pal. New York, 8, pt. 1, 1892, pl. 1, fig. 14). On each side of this pair of concrete laterals there is an additional very faint depression, similar to the pair figured by Hall and Clarke in case of *Lingula iowensis*, but much less distinctly defined. This pair extends forward from the beak a distance of about 5.5 mm., and also attains a width of slightly more than a millimeter, and is limited by a slight elevation anteriorly. Both pairs of shallow cuneate depressions apparently are due to the areas of attachment of muscles which enlarge and shift toward the front with advancing age. Of these areas of attachment there are four, the final location of which is indicated by the crescentic elevations

at the anterior ends of the four cuneate depressions. The cuneate depressions themselves merely indicate the successively advancing former locations of these areas of attachment.

The markings on the interior surface of the pedicel valve may be compared most readily with those figured by Hall and Clarke (loc. cit. pl. 1, fig. 6) in the case of *Lingula procteri* Ulrich, from the upper part of the Cynthiana group, at West Covington, Kentucky. The muscular area extends forward from the beak a distance of 7.5 mm. terminating at the crest of a crescentic callosity crossing the valve transversely near midlength of the shell. From this crest the anterior side of the callosity slopes forward for a distance of 0.6 mm. to the general level of the interior of the valve. Between imaginary radiating lines extending from the beak forward to the antero-lateral angles of the shell, the muscular area is distinctly flattened, this flattened area reaching at its anterior margin a width of 4 mm. Along the median line of this flattened area the surface is slightly elevated, the nearly obsolete cuneate elevation attaining a width of about 0.8 mm. at its anterior margin. The muscular area intrudes for a slight distance, beyond the flattened part, upon the postero-lateral concave part of the interior of the valve. Vascular markings extend from the ridge along the top of the crescentic transverse callosity forward down the anterior slope of the callosity and then along the general interior surface of the valve for a total distance of 2 mm. from the apex of the ridge of the callosity, near the median parts of the shell, becoming successively shorter laterally. Their direction is approximately perpendicular to the curvature of the anterior margin of the muscular area. Similar vascular markings are found in *Lingula vanhornei*, a shell having an outline very similar to that of *Lingula procteri*.

It is not at all improbable that *Lingula brookvillensis* is closely related to *Lingula bisulcata* Ulrich, from the Economy member of the Eden group at Ludlow, Kentucky. *Lingula bisulcata* is a distinctly shorter and broader shell, and the median septum of the brachial valve is much shorter. There is, however, a similar general outline. There is also a similar faint elevation of the median parts of the exterior of the valve, bounded by faint radiating depressions on each side, as in *Lingula brookvillensis*, but no special significance is attached to the latter features since they appear to be quite frequent, although often obsolete in various individuals of the same species, among the quadrangular forms of *Lingula*.

The chief characteristics of *Lingula brookvillensis* are its medium size, rather elongate quadrangular outline, and the thinness of the valves excepting where thickened by callosities. The horizon appears to be near the base of the Richmond group, probably within the Arnheim member.

19. **Trematis crassipunctata,** Ulrich

(*Plate VI, Fig. 6*)

1889. Trematis crassipunctata Ulrich, Amer. Geol., 4, p. 22; 3, p. 378, Fig. 7

The types of *Trematis crassipunctata,* including the specimen figured by Ulrich, belong to the collection of Prof. Charles Schuchert, of Yale University. The species was described from the Fairmount member of the Maysville group at Cincinnati, Ohio.

The type figured by Ulrich is 15.5 mm. in length and 16 mm. in width. It is preserved in clay shale, and at present is rather flattened, but originally it probably had a convexity of 2.5 mm. About 90 radiating striations may be counted at the margin of the shell, but of these only about 50 are present within a radius of 5 mm. from the beak. Along the median parts of the shell anteriorly 5 interspaces, between the radiating striations, occur in a width of 1.7 mm., and the almost rectangular pits here number 5 in a length of 1.6 mm. Along the antero-lateral margins the pits are larger, numbering 5 in a width of 2.8 mm., and 5 in a length of 2.4 mm. In this type specimen, the radiating striations and pits may be traced to the beak.

In the second specimen, accompanying the figured specimen, and labelled as coming from the vicinity of the Lookout House at Cincinnati, Ohio, there are no pits within a distance of 4 mm. from the beak. At first the interspaces between the pits are relatively wide, but become narrow anteriorly, especially beyond 8 mm. from the beak. Along the antero-lateral parts of the shell there are 5 pits in a width of 2 mm., and 5 pits in a length of 1.6 mm.

This species is distinguished chiefly by the large size of the pits between the radiating striæ, and by their strongly quadrangular appearance.

20. **Trematis fragilis,** Ulrich

(*Plate III, Fig 12*)

1873. Trematis punctostriata Hall and Whitfield, Pal. Ohio, 2, p. 70, Plate 1, Fig. 9
1910. Trematis fragilis Foerste, Bull. Sci. Lab. Denison University 16, p. 38, Plate 5, Fig. 2)

The shell here figured is numbered 102 in the James collection at Chicago University. It was found at Cincinnati, Ohio, but the

horizon from which it was obtained is not known with certainty. It was identified by Hall and Whitfield with *Trematis punctostriata*, but that this was an error was pointed out by Schuchert long ago. It is referred with some doubt to *Trematis fragilis* (Ulrich, Amer. Geol., 4, 1889, p. 21, 3, p. 378, fig. 6.) on account of its rotund outline and the general absence of pits over the greater part of the shell excepting along the postero-lateral margins.

The specimen used for figure 8, on plate 1, in the second volume of the Paleontology of Ohio, cited above, appears to be preserved in the American Museum of Natural History, in New York City, where it is numbered 1335-2. The anterior outline of this specimen is more rounded than in the published figure, although the specimen is slightly wider than long. The punctæ are distinct only posteriorly, near the beak, and thence along the margin of the shell as far as the antero-lateral part of the shell. The remainder of the shell is smooth. If the anterior margin of the shell were as moderately convex as figured, this specimen could be identified as *Trematis oblata* Ulrich, but the more rounded anterior margin favors *Trematis fragilis*.

Craniae of the Richmond Group

The Cranias of the Cincinnatian series of rocks offer interesting examples of the influence of the form of supporting surfaces upon the form of closely sessile species. Often even the more minute irregularities of the supporting surface are reproduced in the upper valves of the Cranias.

In such a form as *Crania scabiosa*, the margin of the upper valve is closely applied to the supporting surface, curving up and down on crossing each plication or striation. As the *Crania* enlarges in size, the earlier margins of the upper valves are lifted from the supporting surface and later margins of these valves extend outward. In this manner the details of ornamentation of the supporting surface often are reproduced by the surface of the upper valve of the *Crania* with *remarkable* accuracy of detail. This fact has been known long enough to place such supposed species as *Crania multipunctata, Cr. costata, Cr. asperula,* and *Cr. alternata* among the synonyms of *Crania scabiosa*. The object in calling attention here to these so-called species is not to revive the names once suggested for them, but to place on record what the types suggesting these names actually were, and to let this record stand as an interesting example of the

influence of the form of supporting surfaces upon the form of closely sessile species, such as the Cranias here under discussion.

Similar examples occur among the Cranias found in the Eden group, in the vicinity of Cincinnati, and for these also distinct specific terms were suggested in times past. There is a tendency to include these also as synonyms under *Crania scabiosa*, but a close study of the types of the Eden forms suggests at least the possibility of some of the latter belonging, at least in part, to a distinct species.

21. **Crania scabiosa,** Hall

1868. Crania scabiosa Hall, Descriptions n. sp. Crinoidea and other Foss., p. 13

1872. Crania scabiosa Hall, 24th Rep. New York State Cab. Nat. Hist., p. 220, Plate 7, Fig. 15

1892. Crania scabiosa Hall and Clarke, Pal. New York, 8, pt. 1 p. 148, Plate 4 H, Figs. 23-28, 30, 31

The first figured specimen of *Crania scabiosa* (24th Rep. New York State Cab. Nat. Hist.), here regarded as the type of the species, consisted of a group of individuals attached to *Platystrophia ponderosa*, and evidently was obtained from the upper part of the Maysville group, at Cincinnati, Ohio. The individuals are robust, thick shells, and although conforming to the plications of the supporting *Platystrophia*, they retain also very well the strong concentric lamellose markings which suggested the specific term *scabiosa*. In another specimen, also from Cincinnati, Ohio, and figured by Hall and Clarke (Pal. New York, 8, pt. 1), about thirty individuals, supported upon the brachial valve of *Rafinesquina alternata*, reproduce the radiating striations of the latter distinctly.

Crania scabiosa is abundant also in the Richmond group, especially in the Waynesville member.

22. **Crania multipunctata,** Miller

(*Plate III, Figs. 13 A, B*)

1875. Crania multipunctata Miller, Cincinnati Quart. Jour. Sci., 2, p. 13, Fig. 4

The type of *Crania multipunctata*, numbered 8869, in the Faber collection at Chicago University, is a thin upper valve, 7.5 mm. long, 8 mm. wide, and about 1.5 mm. high. The posterior outline is comparatively straight, and the apex of the valve appears to have been close to this margin, but no traces of concentric or radiating

striæ are seen. The specimen, during life, evidently rested upon some bryozoan, the cells of which have been reproduced to some extent in the surface strcture of the upper valve. Of these cells there were 8 in a length of 2 mm., and these cells were arranged in rows crossing each other diagonally. They are best preserved on the right side of the specimen and near the posterior margin.

Crania multipunctata was described as coming from near the upper part of the hills at Cincinnati, Ohio, and presumably was found in the Corryville member of the Maysville.

23. **Crania costata,** James

(Plate III, Fig. 15)

1879. Crania costata, James, Paleontologist, 3, p. 22)

The type of *Crania costata* is preserved in the Welch collection in the college at Wilmington, Ohio. In its younger stages of growth it evidently was attached to some brachiopod with strong radiating plications, or possibly to some *Byssonychia.* These radiating plications have left their impress upon the *Crania,* traversing the latter in only one direction, and not radiating from the apex of the valve, as in *Crania laelia* and *Crania albersi.* At present, the valve is attached to a fragment of shale. The specimen evidently was obtained from some part of the Richmond, but the exact horizon is unknown.

24. **Crania asperula,** James

(Plate III, Figs. 9 A B)

1879. Crania asperula James, Paleontologist, 3, p. 22

The type of *Crania asperula* is preserved in the Welch collection deposited in the college at Wilmington, Ohio. The fragment of rock to which the Crania is attached shows traces of *Hebertella insculpta, Bythopora delicatula,* and *Helopora harrisi,* and evidently was found in the *Hebertella insculpta* layer at the base of the Liberty member of the Richmond, at Clarksville, Ohio. In its earlier stages at least it was attached to the upper part of the brachial valve of a *Hebertella insculpta,* near the beak, and both the radiating plications, and the much finer transverse striations of this shell have left their impress upon the *Crania.* The latter is regarded merely as an interesting example of *Crania scabiosa* Hall.

25. **Crania alternata,** James

(Plate III, Figs. 10 A, B

1879. Crania alternata James, Paleontologist, 3, p. 23

The type of *Crania alternata,* numbered 1557, is preserved in the James collection, at Chicago University. The width of the shell is 9.5 millimeters; the length, 8 millimeters; and the height, 2.2 millimeters. The upper valve is marked by vertical costæ or striations, due to the radiating plications of the shell upon which this *Crania* grew. Fine, concentric striæ also are present.

The specimen was found near Blanchester, Ohio, probably in the upper or Blanchester division of the Waynesville member of the Richmond, and is regarded merely as one of the many specimens of *Crania scabiosa* which give indications of the surface markings of the shells upon which they grew. The type consists of an upper valve, no longer attached to the shell on which it grew during life, but resting upon the upper surface of a rock fragment containing traces of the former presence of *Leptaena richmondensis,* in addition to better preserved remains of other fossils.

Craniae from the Economy member of the Eden Group

Five species of *Crania* have been described from the Economy member of the Eden group. In their order of publication these species are: *Crania dyeri, Cr. percarinata, Cr. parallela, Cr. socialis,* and *Cr. albersi.* Of these, *Crania dyeri* is characterized by sharp concentric striæ, giving the shell an orbiculoid appearance. *Crania albersi* is characterized by sharp, fine, closely set radiating striæ.

This leaves three species, *Crania percarinata, Cr. parallela,* and *Cr. socialis* which were distinguished originally by features which characterized the shells upon which the Cranias rested, rather than Cranias themselves, since these features were merely reproduced by the Cranias and did not originate with the latter. In searching for features which might be regarded as characteristic of the Cranias it was discovered that among the types of each of these three so-called species there were shells on which granules were present. These granules tend to be elongated in a radial direction, somewhat as in *Crania setigera* from the Trenton of Wisconsin, Iowa, and Minnesota, but they are much more minute than in that species. It would be easy to combine the three so-called species here discussed into a single species characterized by the presence of very minute, radially

elongated granules, if these granules always were present, but the problem is complicated by the failure of these granules to appear in relatively numerous other specimens, otherwise indistinguishable from this group. There is a tendency to regard these species as identical with *Crania scabiosa,* originally described from the Richmond, but the latter do not possess the radially elongated minute granules. I am inclined to regard the Eden group specimens with the minute radiately elongated granules as sufficiently distinct from *Crania scabiosa* when present in large numbers, in which case the chances of detecting the radiately elongated granules are very favorable, but it is quite evident, from the material already examined, that these features can not be depended upon as diagnostic for all specimens, since in relatively numerous specimens they have not been found. Since the term *Crania percarinata* appears first in the publication in which the three so-called species here discussed were described, this name might be used to include at least all of those specimens in which the radiately elongated minute granules can be detected.

Crania socialis is known only attached to crinoid stems. On these supports the shells could not develop symmetrically. Growth in a direction transverse to the length of the crinoid stem was especially restricted, but this retarded growth to a certain extent also in a direction parallel to the length of the crinoid stem. As a result, the shell of *Crania socialis* appears not only abnormally elongated but also abnormally thickened. The fact that the apex in some specimens appears near one end of the elongated shell, and in other specimens near the middle of one of the sides suggests that the elongation is due to the character of the support and has no specific value. It, therefore, appears to me to differ from those specimens of *Crania percarinata* and *Crania parallela* which have radiately-elongated granules only in features dependent upon the form of the support which they accidentally chose.

Detailed description of the types are given on the following pages.

26. **Crania dyeri,** Miller

1875. Crania dyeri Miller, Cincinnati Quarterly Jour. Sci., 2, 13, Fig. 3

The type of *Crania dyeri* is numbered 1758 in the Dyer collection at Harvard University. It is cited by Bassler, in his Bibliographic Index of American Ordovician and Silurian Fossils, only from the

Economy member of the Eden group, at Cincinnati, Ohio. The length of the type is 5 mm., the width is only slightly less, and the height is about 1.7 mm. The apex is about two-fifths of the length of the shell from the posterior margin, so that the concentric striæ are crowded posterior to the apex. The concentric striæ are thick, strong, and salient for a shell of such small size. The prominence of the striæ becomes gradually less from the margin toward the apex. The exterior three are strong, the next three vary from medium to fine, and the last three, toward the apex, are almost obsolete in the type, but this may be due in part to wear.

A second specimen, in the Dyer collection, is slightly larger, and is marked by 12 concentric striæ. The outer striæ in this specimen are not so strikingly larger and coarser than those nearer the apex as in the type specimen.

27. **Crania percarinata,** Ulrich

(Plate VI, Fig. 1; Plate IV, Fig. 7)

1878. Crania percarinata Ulrich, Jour. Cincinnati Soc. Nat. Hist., 1, p. 98, Plate 4, Fig. 12

1892. Crania percarinata (=Crania scabiosa Hall) Hall and Clarke, Pal. New York, 8, pt. 1, Plate 4H, Fig. 30

The types of *Crania percarinata* belong to the collection of Prof. Charles Schuchert, of Yale University, and were found in the Economy member of the Eden, about 100 feet above low water in the Ohio river, at Covington, Kentucky.

The specimen illustrated by figure 30, in the Hall and Clarke publication cited above (fig. 1 on plate VI and fig. 7 on plate IV of present bulletin), is 3 mm. in length, 4.1 mm. in width, and has a convexity slightly exceeding one millimeter. In life it was attached to a specimen of *Lophospira lirata* Ulrich, which probably is identical with the species described by James as *Murchisonia ohioensis.* The upper valve of this *Crania carinata,* the only valve known, reproduces in a remarkable manner even the minute striations of that part of the *Lophospira* upon which it grew. The specimen rested directly upon the trilineate slit-band and extends from this band upward sufficiently to include the carina on the upper slope of the whorl, and downward beyond an apparently nearly obsolete carina on the lower slope. The markings on the *Crania* indicate that the slit-band had a width of 0.7 mm., transverse striæ approach this slit-band both from the upper and lower slopes of the whorl so as to curve

strongly backward in the immediate vicinity of the band, in crossing this band the striæ present a concave curvature toward the peripheral notch, and the median striation of the slit-band is almost as sharply defined as the limiting striations of this band. All of these are features in exact accordance with typical *Lophospira lirata*, or at least its variety *obsoleta*.

In searching for the features which are characteristic of the species *Crania percarinata* it is necessary to ignore those striations which evidently are merely reproductions of the surface characteristics of the *Lophospira* upon which the *Crania* rested. In searching for these features it is noted that the shell is marked by the concentric striations found in practically all Cranias. It is a part of one of these concentric striations, in addition to a small deformation due to compression, which is incorrectly figured by Hall and Clarke on the right side of their figure, which is so oriented as to place the peripheral notch on the right. Gasteropoda, however, are more commonly placed with the apex at the top, which would cause the peripheral notch to open toward the left side of the whorl. In addition to the concentric striæ there are traces, along one margin, of very minute granules arranged more or less in radiating lines. The latter are regarded as characteristic of one Eden species, of which *Crania percarinata* apparently is the first described specimen.

The specimen represented by figure 31, in the Hall and Clarke publication, evidently rested upon a *Conularia*, somewhere near its apex, where the width of one of the four faces could not have exceeded 3 mm. The surface of the *Crania* reproduces in minute detail the surface features of the *Conularia*: the longitudinal groove at one angle of the Conularia, the slightly concave depression along one of the sides of the *Conularia*, the sharply defined transverse striations rising in the form of a very broad inverted V if the specimen be held with the larger end of the *Conularia* toward the top. Of these transverse striations there are about 18 in a length of 3 mm. The short striations within the grooves between these transverse striations are at right angles to the latter and may be detected readily along one part of the *Crania*. The figure presented by Hall and Clarke is so oriented that if the supporting *Conularia* were present, the pointed apex of the latter would be directed toward the right of the figure, and the vertical groove along the angle should be along the lower third of the figure.

Ignoring these surface features, which are merely a reproduction of those belonging to the supporting *Conularia*, a few concentric markings may be seen along the margin of the *Crania*, but no minute granulations arranged along radiating lines.

28. **Crania parallela**, Ulrich

(Plate VI, Figs. 2, 3)

1878. Crania parallela Ulrich, Jour. Cincinnati Soc. Nat. Hist., 1, p. 98, Plate 4, Fig. 13

The types of *Crania parallela*, including the specimen figured in the original publication, belong to the collection of Prof. Charles Schuchert, of Yale University, and were found in the Economy member of the Eden group, about 100 feet above low water in the Ohio river, at Covington, Kentucky.

In the figured specimen, (fig. 13 of original publication; fig. 2 on plate VI of present bulletin) one side of the shell has been broken off but originally it must have been about 8 mm. in width. About 16 nearly straight ridges cross the shell vertically. Of these ridges there are 14 in a length of 5 millimeters. In the narrow grooves between these ridges there are indications of numerous short striæ perpendicular to the ridges, suggesting that the *Crania* was attached to a *Conularia*. Aside from these features, which evidently do not constitute a specific characteristic of the *Crania*, there are numerous very minute granules scattered quite irregularly over the surface, with only a faint tendency toward radial arrangement. These granules are regarded as characteristic of an Eden species which has been described under several names based on surface features shown by individual specimens, and which vary with the character of the supporting surface.

A second specimen, B, 6 mm. in width, was attached to one of the faces of a *Conularia*. There are 12 transverse ridges in a length of 3 mm. These ridges meet at an angle of 130° at the middle of the face of the *Conularia*. The short vertical ridges in the grooves between these ridges are very plainly shown. Minute granules characteristic of the *Crania* rather than of the *Conularia* apparently may be detected.

A third specimen, C, (figure 3 on plate 6, in this bulletin), 6 mm. in width, is crossed at irregular intervals by moderately

diverging striations, which evidently reproduce the markings on the surface of the shell upon which the *Crania* rested. In addition to these striations, this specimen is marked by numerous very minute granules which are arranged in an irregular manner but are elongated in a radial direction, locally producing the appearance of scattered, very short radial striæ. In no other specimens are these minute granules better defined, and hence this specimen C may be regarded as most typical of those lower Eden forms of *Crania* which are characterized by the presence of minute granules. These forms, probably constituting a single Eden species, have been described under various names suggested by surface features conditioned by the supporting surface.

In a fourth specimen, D, 5 mm. in width, sharp, transverse striations with finer intermediate striæ occur at irregular intervals, but there are no traces of granules.

In a fifth specimen, E, 9 mm. in width, the transverse striations are sufficiently broad to suggest that the *Crania* rested upon a *Byssonychia*. Eight of these striations, or rather plications, occupy a width of 4 millimeters. There are also concentric markings but no trace of granules. In another *Crania* upon the same rock fragment, but without transverse striations, very minute fibrous lines, much more minute than the granules and radiating lines mentioned in the description of any of the other Cranias from the lower Eden, radiate from the strongly excentric apex toward the circumference of the nearly circular shell. The latter is 4.3 mm. in width. In addition to this, the inner side of one of the valves of this *Crania*, 4.5 mm. in diameter, is exposed.

In a sixth specimen, F, about 4 mm. in width, there is the same irregular alternation of coarser and finer sharp striæ as in specimen D, suggesting that the supporting shell may have been a gasteropod, but there are no indications of minute granules. Another specimen on the same rock fragment does not present any cross-striations, due to support on a striated shell. As in the case of the nearly circular *Crania* associated with specimen E, the apex is very excentric, there are numerous fine concentric striæ, and a few traces of exceedingly minute fibrous radiate structure of an indefinite character. The length of this specimen is 5 mm., the width is 5.8 mm., and, in the present flattened condition of the shell, the apex is about 1.7 mm. from the posterior margin.

29. **Crania socialis,** Ulrich

(Plate VI, Fig. 4; Plate III, Figs. 11 A, B)

1878. Crania socialis Ulrich, Jour. Cincinnati Soc. Nat. Hist., 1, p. 98, Plate 4, Fig. 14

1892. Crania socialis Hall and Clarke, Pal. New York, 8, pt. 1 Plate 4 H, Fig. 29

The types of *Crania socialis,* including in addition to the specimens figured by Ulrich and by Hall and Clarke in the publications cited above, also several additional specimens, belong to the collection of Prof. Charles Schuchert, of Yale University, and were found at different elevations in the Eden group at Cincinnati, Ohio.

The type figured by Ulrich (fig. 4 on plate 6 of present bulletin), is a free upper valve resting upon a rock fragment containing *Cryptolithus tessellatus* (*Trinucleus concentricus*), and probably was found in the lower half of the Eden group. It is 2 mm. in length, 4.5 mm. in width, and has a convexity of about two-thirds of a millimeter. It is crossed by 7 vertical ridges, evidently representing the same number of columnals on that part of the crinoid stem to to which it was attached. There are faint traces of minute concentric striæ but no evidences of granules or radiating striæ.

The specimen figured by Hall and Clarke consists of a circular crinoid stem about 12 mm. in length and 3.3 mm. in diameter, with 14 columnals, alternating in size, in a length of 10 mm. Both the larger and smaller columnals are repeated in the broad ridges crossing the Cranias. Of the latter, there are 10 attached to the crinoid stem fragment. The longest diameter of the Cranias is parallel to the length of the crinoid stem. There is no clear evidence of minute radiating striæ.

In a third specimen, C, there are 10 Cranias attached to a crinoid stem fragment 17 mm. in length; of these 6 are quite conspicuous, and on one of them radiating striæ diverge very distinctly from an apex situated near one end of the longest diameter of the specimen. On one of the other shells these markings appear more like granules strongly elongated in a radial direction; in this shell the apex is situated along the shorter diameter.

Traces of radiately elongated granules are seen also on Cranias attached to specimens D, and E.

One of the most elongated shells occurs on Specimen F. In this shell the length is 7.5 mm., the transverse diameter is 2.2 mm. and the apex at present rises fully 2 mm. above the curvature of

the crinoid stem, but this evidently is due in part to compression parallel to the shorter axis of the shell. Only very obscure traces of elongated granules are noticed at one point along the margin of the shell.

Another specimen of *Crania socialis* is numbered 8868 in the Faber collection at Chicago University. It consists of 17 larger and 10 considerably smaller shells attached to a crinoid stem 22 mm. long and 3.5 mm. in diameter. At first sight this group of shells appears merely like numerous specimens of *Crania scabiosa*. Their surfaces are comparatively smooth, and there are traces of concentric striæ, although these are not very conspicuous. On closer examination, however, very fine radiating lines are noticed, which apparently consist of irregularly arranged short striæ directed in a radiating direction. These striæ are preserved best along the younger parts of the shells, along the margin, the older, more central parts, being smooth.

30. **Crania albersi,** Miller and Faber

(*Plate III, Figs 8 A, B*)

1894. Crania albersi, Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., 17, p. 154, Plate 8, Figs. 17-19

The type of *Crania albersi*, No. 8863 in the Faber collection at Chicago University, consists of an upper valve resting upon a specimen of *Zygospira modesta*. The *Crania* evidently was not attached to the *Zygospira* during life, but the upper valve of the *Crania* had become loosened from its original area of attachment and had drifted to its present position, on top of the *Zygospira*, before becoming buried in the sea mud. Its original support must have been some shell with much narrower and less divergent markings than the plications of *Zygospira modesta*, judging from the narrow, subparallel plications, approximately vertical to the posterior margin, which are shown by the type, and which evidently are superimposed upon the fine radiating striæ characteristic of the species of *Crania* under discussion. The supporting shell may have been some species of *Rafinesquina*. The length of the type specimen is 4 mm.; the width can not be determined with accuracy since the margin on the right side of the specimen is broken away for its entire length, but this width is estimated at 5.3 mm., and the height of the valve is about 1.5 mm. Along the margin of this type, the number of radiating striæ varies from 6 to 8 in a width

of one millimeter. *Crania albersi* was described from the Economy member of the Eden group at Cincinnati, Ohio. The fragment of rock supporting the *Crania* contains also traces of *Cryptolithus tessellatus* Green.

Compared with *Crania laelia* Hall, from the Maysville and Richmond groups of Ohio and Indiana, *Crania albersi* is less rotund, has a more definite and straighter posterior margin, the apex is nearer this posterior margin, and the radiating striæ are finer.

31. **Whitella cuneiformis,** Miller

(Plate VII, Figs. 1 A, B, C)

1881. Orthodesma cuneiforme Miller, Jour. Cincinnati Soc. Nat. Hist., 3, p. 314, Plate 8, Figs. 1, 1a

1889. Sphenolium cuneiforme Miller, genotype, N. A. Pal., p. 513

The type of *Orthodesma cuneiforme* is numbered 8803 in the Faber collection at Chicago University. It is labelled as coming from Versailles, in Indiana, and probably came from the Waynesville member of the Richmond formation. It evidently belongs to the group of shells typified by *Whitella sterlingensis* Meek and Worthen, for which Meek proposed the generic term *Rhynchotropis*, without describing this genus, however. *Whitella sterlingensis* is a typical fossil of the Maquoketa member of the Richmond, in Illinois and Minnesota. *Whitella hindi* Billings, from the Lorraine on the Humber river, at Toronto, in Ontario, belongs to the same group.

This group of shells is characterized chiefly by the great elongation of the shell in a direction parallel to the umbonal ridge, the latter being strongly oblique to the hinge-line. The hinge-line extends only a moderate distance anterior to the beak, and the extension posterior to the beak is much shorter than the distance from the beak to the posterior termination of the shell along the umbonal ridge. Ventrally, the umbonal ridge rounds gradually into the general curvature of the shell as far as the ventral margin, but dorsally the shell is strongly compressed, especially anteriorly, toward the beaks, so as to produce a flattened appearance when examined from above. Posterior to the beaks, there is a well defined escutcheon.

The type of *Orthodesma cuneiforme* is an internal cast. Its length from the beaks to the posterior margin, along the umbonal ridge, is 80 mm.; its thickness from valve to valve is 3.6 mm. The distance along the hinge-line from the tips of the beak to the posterior end of the hinge-line is estimated at 30 mm.; anterior to the beak the hinge-line extends between 5 and 7 mm. With this hinge-line the umbonal ridge forms an angle of about 50 degrees. The type is defective along the basal margin and along the entire posterior margin, but enough is preserved to indicate the general outline.

In a second specimen of Whitella cuneiforme, presented to me by Prof. W. H. Shideler, of Miami University, obtained somewhere in the lower part of the Richmond in Warren county, Ohio, the basal margin is well preserved, and more is preserved of the parts bordering on the posterior margin. This shell differs from the type only in having the umbonal ridge more inflated anteriorly, so that a moderately concave curvature exists between the anterior half of the umbonal ridge and the anterior half of the basal margin of the shell.

The specimen figured by Miller and Faber as *Sphenolium cuneiforme* (Jour. Cincinnati Soc. Nat. Hist., 17, 1894, p. 141, pl. 8, figs. 5, 6), from the same locality as the type of that species, was incorrectly identified. It forms No. 8792 in the Faber collection at Chicago University, is labelled as coming from Versailles, in Indiana, and evidently is a species of *Modiolopsis*. The specimen is badly crushed along the umbonal ridge posteriorly, and all of the upper part, posterior to the beak, is missing. The shell, originally, was only moderately convex, the mesial depression anterior to the umbonal ridge was weakly defined, there was no concave curvature along the base, and if *Modiolopsis versaillesensis* ever attained so large a size, these incorrectly identified specimens probably belonged to that species.

32. **Whitella richmondensis,** Miller

(Plate VII, Figs 2 A, B, C)

1889. Sphenolium richmondense Miller, N. A. Geol. Pal., p. 513, Figs. 925, 926

The type of *Sphenolium richmondense* is numbered 8800 in the Faber collection at Chicago University. It is labelled as coming

from Richmond, in Indiana, and is assumed to have been obtained in the Whitewater member of the Richmond group. The specimen is altogether too poor to merit its use as a type of a new species. The small anterior extension of the shell, the prominent umbonal ridges, the rhombic-cordate outline of the shell when viewed from the front, the steep post-umbonal slopes of the shell extending from the umbonal ridge to the dorsal margin, and the extreme thinness of the shell, as far as may be determined from the parts preserved, all suggest the affinity of this type specimen with some species of *Whitella*.

Compared with *Whitella cuneiformis*, the posterior slope of the umbonal ridge is distinctly less flattened, and the curvature between the umbonal ridge and the dorsal margin is distinctly more concave; moreover, the shell does not appear to have been so strongly elongated. The absence of strong flattening along the posterior slope of the umbonal ridges distinguishes this type also from *Whitella hindi* Billings and *Whitella sterlingensis* Meek and Worthen. The general outline, as far as may be judged from the imperfect specimen at hand, was much more oblique than in *Whitella quadrangularis* Whitfield or *Whitella subovata* Ulrich. Compared with *Whitella umbonata* Ulrich, the umbones are far less prominent. Compared with *Whitella obliquata* Ulrich, the umbones appear more gibbous and the outline of the shell is more broadly cordate when viewed from the front. From both *Whitella obliquata* and *Whitella ohioensis* Ulrich it differs in being narrower anteriorly, the anterior part of the basal margin being less convex and more nearly parallel to the umbonal ridge. In other words, *Whitella richmondensis* does not appear to be identical with any of the species of *Whitella* described from the Cincinnatian beds of Ohio or Indiana. This, however, might easily be explained by the fact that all of the latter have been described from the Waynesville member of the Richmond, while *Whitella richmondensis* probably was obtained from the Whitewater member, and may be a distinct species. It must be acknowledged, however, that the type does not give much definite information as to the characteristics of this species. The most disconcerting fact about the type is the presence of a distinct elevation along that part of the hingeline, posterior to the beaks, where the escutcheon ought to be. I have assumed that this elevation is, in part at least, a remnant of the matrix, and that well preserved specimens, exposing this part of the shell, would show an escutcheon.

33. **Cyrtodonta cuneata,** Miller

(Plate VII, Figs 3 A, B, C, D)

1878. Angellum cuneatum Miller, Jour. Cincinnati Soc. Nat. Hist., 1, p. 106, Plate 3, Fig. 11

1908. Cyrtodonta cuneata Cumings, 32d Ann. Rep. Dep. Geol. Nat. Res. Indiana, p. 999, Plate 45, Fig. 2

The type of *Angellum cuneatum* is numbered 8815 in the Faber collection at Chicago University. It is labelled as coming from Richmond, Indiana, and lithologically appears as though it had come from the Whitewater member of the Richmond. The specimen has been so strongly carved by some one who desired to clean the specimen, that its present form is more manufacutred than natural. This is true especially of the part immediately anterior to the beak and of that part of the anterior margin where a cast of an anterior muscular scar has been carved out in a very unnatural location, far below the position which it must have occupied.

The type evidently is a cast of the interior. The beaks appear to have been small and narrow. An angular ridge extends ventrally from the beak, in this cast, but disappears at a point slightly more than half way from the beak to the ventral margin. Anterior to the beak, a small but deep lunule has been carved out, and posterior to the beak a high hinge area is seen. It is evident that the greater part of the posterior portion of the shell is absent, but traces of concentric striæ suggest that the shell was comparatively short.

There is a possibility of *Angellum cuneatum* being related to *Bodmania insuetum,* a species also described from the Whitewater at Richmond, Indiana, (1894, Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., 17, p. 23, pl. 1, figs. 5-7), apparently another Cyrtodontoid form, but the latter appears to have had more prominent and inflated beaks, giving it a much more broadly rhombic-cordate outline when viewed from the front. The attempted restoration of the posterior parts of this type, as shown by figure 3C on plate VII, may be regarded as a wild guess.

34. **Anomalodonta alata,** Meek

(Plate IV, Fig. 2)

1872. Ambonychia alata Meek, Proc. Acad. Nat. Sci. Philadelphia, p. 319

1873. Ambonychia alata Meek, Geol. Surv. Ohio, Pal. 1, p. 131, Pl. 11, Fig. 9, Plate 12, Fig. 10

Both of the types figured by Meek in the Paleontology of Ohio, cited above, are numbered 2341 in the James collection at Chicago

University. Both of these types are impressions of the exterior of right valves, preserved in limestone. The original of figure 9 on plate 11 occurs in limestone containing numerous fragments of *Rafinesquina alternata* but only one fragment of *Dalmanella jugosa;* a single squarish columnal, possibly belonging to *Compsocrinus,* also is present. Twenty-four radiating plications are indicated plainly but the margin of the byssal opening is not preserved, so that there may have been one or two additional plications in this region. The original of figure 10 on plate 12 appears to have come from the same rock layer as the original of the specimen just described. Twenty-eight radiating plications can be recognized readily and in addition to these there were probably one or two more in the region of the byssal opening. Both of these types probably were derived from the Waynesville member of the Richmond group, at Clarksville, in Clinton county, Ohio.

A third specimen, also numbered 2341, but evidently not at hand at the time the figures of the types were prepared, since it is a much better specimen than the other two and presents a well preserved and nearly entire left valve, is included in rock containing *Dalmanella jugosa,* several square columnals suggesting *Compsocrinus,* and various minute ostracods. The specimen is especially interesting in presenting an excellent example of the margins of the different stages of growth (in this case, four stages) remaining free from the main body of the shell, producing more or less squamose concentric bands.

The specimen figured in this bulletin was obtained by the writer on Clifty Fork, west of Madison, Indiana, a considerable distance below the lowest horizon in the Waynesville member of the Richmond group at which *Dalmanella jugosa* is found. The thickness of this shell from valve to valve is 27 millimeters. Twenty-four radiating plications are exposed and the original number may have equalled twenty-eight.

The distinguishing features of *Anomalodonta alata* are the rather concave anterior outline, the moderately sinuous posterior outline with the moderate prolongation of the shell along the hinge-line, and the relatively moderate width of the interspaces between the radiating plications, which may equal the latter but frequently are somewhat narrower. Toward the antero-ventral margin of the shell, the plications curve moderately forward. Most of the plications originate at the beak, but along the hinge-line and on the

anterior slopes of the shell there frequently is evidence of the intercalation of one or two additional plications.

35. **Anomalodonta costata,** Meek

(Plate IV, Fig. 3)

1873. Ambonychia costata Meek, Geol. Surv. Ohio, Pal., 1, p. 130, Plate 12, Figs. 5, a, b, c

The type of *Anomalodonta costata* is numbered 790 in the James collection at Chicago University. It posseses 19 simple radiating plications but the original number may have equalled 24. Compared with *Anomalodonta alata,* the radiating plications are distinctly narrower and are separated by relatively broader interspaces, which on account of their considerable width appear comparatively flat. *Anomalodonta costata* is a smaller species, usually not exceeding 50 mm. in height. The concave curvature of the anterior margin and the sinuous curvature of the posterior margin are both less, and the latter can scarcely be said to be alate; both of these features are possessed also by *Anomalodonta alata* during its younger stages. The posterior margin of *Anomalodonta costata* rarely is well preserved but its direction is indicated frequently by the direction of the concentric striæ upon such parts of the shell as remain. The type is labelled as coming from Cincinnati, Ohio, but the horizon of the species is known to extend from the Arnheim, where frequently it is common, into the Waynesville member of the Richmond. As in the case of *Anomalodonta alata,* one or two additional plications are intercalated occasionally along the hinge-line or on the anterior slope of the shell. The total number of plications may reach 27 or 28.

36. **Byssonychia robusta,** Miller

(Plate IV, Figs 1, A, B, C)

1881. Ambonychia robusta Miller, Jour. Cincinnati Soc. Nat. Hist., 3, p. 315, Plate 8, Figs. 3, 3a

1893. Byssonychia richmondensis Ulrich, Geol. Surv. Ohio, 7, p. 632, Plate 45, Figs. 3, 4

The types of *Byssonychia robusta* are numbered 8816 in the Faber collection at Chicago University. They are described as coming from near Osgood, in Indiana, but are labelled as coming from Versailles, Indiana. At both localities, and at numerous in-

termediate points, *Byssonychia robusta* occurs associated with *Dystactospongia madisonensis* at the base of the massive *Tetradium* layer at the base of the Saluda member of the Richmond group. The original of the type represented by figure 3, accompanying the original description, is used for figures 1A, 1B in the present bulletin. The original of figure 3a accompanying the original description is represented in this bulletin by figure 1C. The latter specimen is unquestionably a typical example of the species described later by Ulrich as *Byssonychia richmondensis*, and is evidently the type which Miller had in mind when he described the species as having its "anterior side flattened and depressed in the region of the byssus; beaks acute, triangular," and refers to the "abrupt bending over of the shell on its anterior side."

Formerly I thought that the original of the figure 3, presented by Miller, might represent a relatively broader species, distinct from *Byssonychia richmondensis*. Later, however, I had the opportunity of seeing hundreds of specimens of *Byssonychia robusta* at its type horizon, where it often is very abundant, and it soon became evident that the broader specimens, as represented by the specimen used for figure 3, by Miller, were the normal forms, while the more elongate forms, suggesting *Byssonychia richmondensis*, as figured by Ulrich, showed indications of compression anteroposteriorly. This compression not only gave a more elongate appearance to the shell, but made the angular bending of the shell along the umbonal ridge more abrupt, and made both the plications and the interspaces between these plications more narrow, although of course, not changing their number. From this it must not be assumed that the broader form, used by Miller for figure 3, does not show any abrupt bending over of the shell anteriorly. This abrupt bending is confined usually to the upper half of the shell. Along the lower half, the umbonal ridge is merely strongly rounded. The very angular, almost acutely angular bending of the shell is confined to those parts within 20 mm. of the beak, and from this distance downward the angularity of the umbonal ridge gives way gradually to more and more pronounced rounding. In this respect the original of figure 3, as published by Miller, was as typical as the original of his figure 3a, but in the former specimen the shell is not preserved along the angle of the umbonal ridge near the beak, but comparison with numerous other specimens from which the shell substance has been removed indicates that the cast of the interior

of this valve along the upper part of its umbonal ridge is perfectly normal for the species, as typified by numerous specimens, entirely uncompressed, found at the type horizon.

In more recent years I have found specimens of *Byssonychia richmondensis* as far off as Manitoulin island, and there also have noted the evidence of moderate antero-lateral compression resulting in a more elongate appearance of the shell, and in a greater angularity along the umbonal ridge.

If *Byssonychia richmondensis* of Ulrich represents a form distinct from those which I have identified as equivalent to his species, then I have never seen his species.

In *Byssonychia robusta* there are about 30 to 33 radiating plications posterior to the sharpest part of the umbonal ridge, and 8 or 9 additional ones between this part of the umbonal ridge and the base of the byssal opening. The species occurs both in the Saluda and in the Whitewater members of the Richmond, the former being regarded as chiefly a southern more arenaceous, less fossiliferous phase of the greater part of the Whitewater and of a small part of the Elkhorn member of the Richmond group, as exposed farther north in Indiana.

37. **Cymatonota cylindrica,** Miller and Faber

(Plate VI, Figs. 7 A, B)

1894. Orthodesma cylindricum Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., 17, p. 22, Plate 1, Figs. 1-4

The types of *Orthodesma cylindricum* are numbered 8801 in the Faber collection at Chicago University. They are described as coming from above the middle of the Cincinnatian series of rocks in Warren county, Ohio, but are labelled as coming from Cincinnati, Ohio. Of the specimens figured by Miller and Faber, the one used for figure 1 is missing. The specimen used for figures 2 and 3 is fairly well preserved, and is illustrated in the present bulletin. The original of figure 4 is considerably distorted but shows the characteristic wrinkles along the hinge-line and the concentric striæ of the general surface of the shell very well. The type evidently is identical specifically with *Cymatonota typicalis* described by Ulrich from the Waynesville member of the Richmond group at Waynesville, Ohio. Miller and Faber's description was published in 1894, while Ulrich's description, was published, in volume 7 of the Geology of

Ohio, in 1893, so that the term *Cymatonota typicalis* has precedence.

The specimen figured in this bulletin is 66 mm. long, 15 mm. high at the beak, 18 mm. high at the rear, and 11.5 mm. thick from valve to valve. The thickest part is near mid-length, or a short distance posterior to mid-length, and from this point the shell tapers gradually in both directions, gaping at the ends. Only the stronger concentric markings are preserved, the finer striations being absent. Oblique wrinkles border the hinge-line for a distance of 25 mm. posterior to the beak. The beaks are strongly flattened and approach each other closely. Along the area marked by oblique wrinkles, the umbonal ridge diverges but moderately from the level of the hinge-line, and then curves more rapidly toward the lower posterior angle. The very shallow mesial depression extends for almost the entire length of the shell, producing a slight concave curvature along the basal margin of the shell. The anterior end of the shell is almost evenly rounded and extends about 13 mm. anterior to the beak.

38. **Modiolopsis versaillesensis,** Miller

(*Plate IV, Fig. 4*)

1874. Modiolopsis versaillesensis Miller, Cincinnati Quart. Jour. Sci., 1, p. 150, Figs. 13, 19

1894. Modiolopsis versaillesensis, Ulrich, Geol. Minnesota, 3, pt. 2, p. 521, Fig.40a

Three left valves, numbered 8791 in the Faber collection at Chicago University, are labelled as *Modiolopsis versaillesensis* and as coming from Versailles, Indiana. Of these, the largest specimen is regarded as the original of figure 18 accompanying the original description, and another figure of the same specimen is presented in the present bulletin. All three specimens evidently came from the *Cycloconcha milleri* horizon in the Waynesville member at Versailles, Indiana. Compared with the figure presented by Miller, the beak is less prominent anteriorly; otherwise the agreement is quite close. The type is 45 mm. long, has a maximum height of 25 mm., and the thickness from valve to valve is about 14 or 15 mm. judging from the convexity of the single valve here measured. Concentric striations are well marked along the anterior margin and along the post-umbonal slope near the hinge-line; along the ventral margin of the shell they are only moderately distinct, and toward the umbonal ridge they frequently are faint. The shell is only moderately convex. The umbonal ridge is distinctly but not

strongly indicated. The mesial depression anterior to the umbonal ridge is slight. There practically is no mesial sinus along the ventral margin, the latter being straight along the base of the mesial depression.

39. **Modiolopsis brevantica,** n. sp.

(Plate V, Figs. 1 A, B)

Species apparently belonging to the same group as *Modiolopsis concentrica,* but much more convex. Anterior margin sloping obliquely downward, and projecting only 3 millimeters anterior to the beak. Posterior part of the cardinal margin only slightly convex for a distance of 15 millimeters from the anterior part of the beak, and then deflected downward at an angle of about 140 degrees. The umbonal ridge has about the same direction, 140 degrees with the horizontal. The shell is swollen out along the umbonal ridge, the greatest distance from valve to valve equalling 12 millimeters, at a distance of 12 millimeters from the beak. The shell is vertically compressed along the base, but it is evident from the concentric lines ornamenting the surface that it was long and slender. The base has about the same direction as the umbonal ridge, and therefore also forms an angle of about 140 degrees with the horizontal. The lowest part of the base reaches about 21 millimeters below the horizontal continuation of the hinge-line. The greatest width of the shell between the basal and posterior outlines equals about 16 millimeters. Both anteriorly and posteriorly the shell is quite evenly rounded. The mesial sinus is shallow and not strongly defined. The umbonal ridge is fairly angular anteriorly and is much more strongly defined than in *Modiolopsis concentrica.* The beaks are small and approach each other closely. The preumbonal slopes are flattened. Viewed from above, the shell has an elliptical-lanceolate outline. The surface is quite strongly ridged concentrically, 7 ridges occupying a length of 5 millimeters along the umbonal ridge.

Found in the Waynesville member of the Richmond at Clay cliff, 3 miles north of Wekwemikongsing, on the eastern shore of Manitoulin island, Canada.

40. **Pholadomorpha pholadiformis,** Hall

1851. Modiolopsis pholadiformis Hall, Geol. Lake Superior Land. Dist., Foster and Whitney Rep., p. 213, Plate 30, Figs. 1 a-c; Plate 31, Fig. 1

Pholadomorpha pholadiformis is characterized so strongly by its peculiar surface ornamentation that it seems almost incredible

that it could have been described under three different names by the same individual, Miller. One of these so-called species merely is due to obliquely vertical compression of the shell in the soft shale and in the original Miller collection was represented by numerous specimens differing so widely among each other in the location of the so-called plications or sulcæ that suspicion certainly should have been aroused as to the specific value of these features. A second one of these so-called species represents merely a specimen preserved in soft shale and crushed flat while lying on its side. The third specimen was preserved with a limestone matrix filling its interior, and this specimen retains not only its original shape but part of the shell substance itself. These so-called species were described as *Modiolopsis sulcata, Modiolopsis corrugata,* and *Modiolopsis capax.*

For the fourth term, *Sedgwickia divaricata,* proposed by Hall and Whitfield, there is more excuse. The specimen is a much younger one than those found ordinarily, and the plications are very strongly marked for such a young specimen, presenting a very unfamiliar appearance.

These so-called species are described and figured on the following pages in order to put on record what they really are.

It is probable that the present writer has himself added to this list of synonyms by describing a Canadian specimen, very much like the *Modiolopsis capax* of Miller, as *Pholadomorpha chamblien-sis.*

41. **Pholadomorpha divaricata,** Hall and Whitefield

(Plate V, Figs. 3A, B, C)

1875. Sedgwickia ? divaricata Hall and Whitfield, Geol. Surv. Ohio, Pal., 2, p. 89, Plate 2, Fig. 3

1914. Pholadomorpha pholadiformis divaricata Foerste, Bull. Sci. Lab. Denison Univ., 17, p. 279, Plate 2, Fig. 14

The type of *Sedgwickia divaricata* is preserved in the James collection at Chicago University, and is there numbered 1489. It was described as found in the shales of the Hudson River (Cincinnati) group, at Blanchester, Ohio. The best exposures in the vicinity of Blanchester occur about a mile west of town, along the creek about a quarter of a mile north of the railroad. Here the upper or Blanchester division of the Waynesville member of the Richmond is exposed, but the immediately underlying parts of the middle or

Clarksville division are seen farther westward, along the same stream. From this it is assumed that the type was found in the upper part of the Waynesville. Three figures of the type are given in this Bulletin.

There is no doubt of this type being merely the young of some species of *Pholadomorpha*, presumably *Pholadomorpha pholadiformis*. The figure accompanying the original description is slightly enlarged in the effort to represent the specimen as entire, and the prominence of the beak and of the umbonal ridge is greatly exaggerated. The basal margin is less convex than in this figure, especially posteriorly. The concentric wrinkles are strongly defined in case of the right valve, less strongly in case of the left valve. Along the cardinal margin these concentric wrinkles form angles of about 40 degrees with this margin; here they are fairly well defined if held transversely to the light. The chief difficulty in recognizing those parts of the concentric wrinkles which border on the cardinal margin is the presence of the transverse plications which make their appearance within 8 millimeters of the beak, and become more prominent posteriorly. On this account, only those concentric wrinkles which are near the beak are recognized readily on the postumbonal slopes. The transverse plications on the slope beneath the umbonal ridge are low and broad, but distinctly defined.

There is no reason for believing that *Sedgwickia divaricata* represents a distinct species. It is merely a specimen of *Pholadomorpha pholadiformis* in which both the concentric wrinkles and the transverse plications were strongly defined even at an early stage of growth. This suggests that at mature age this type would have been characterized by strongly marked transverse plications even along the postumbonal slopes, as in the specimen figured as *Pholadomorpha divaricata* from the Richmond of the Rivière des Hurons, in the province of Quebec, in this Bulletin, volume 17, on plate 2. It is not certain, however, that the type of *Sedgwickia divaricata* would have developed into a form with as strongly divergent cardinal and basal margins as the latter specimen.

42. **Pholadomorpha capax**, Miller

(Plate V, Figs. 4A, B)

1889. Modiolopsis capax Miller, N. A. Geol. Pal., pp. 489, 490, Fig. 851

The type of *Modiolopsis capax*, figured in this Bulletin, forms No. 8802 in the Faber collection at Chicago University, and retains

also the number 407 which it had in the Faber collection. It was obtained at Versailles, Indiana, presumably in the Waynesville division of the Richmond. The shell unquestionably belongs to the *Pholadomorpha pholadiformis* group, and, if it differs at all from the latter species, this difference consists chiefly in a smaller deviation between the cardinal and basal margins. However, there is a probability that in a perfect condition of the shell the cardinal margin would be straighter for a longer distance posteriorly, and that the basal margin would deviate more from the cardinal margin. Accepting this interpretation, the type of *Modiolopsis capax* is less interesting as a possible new species than as an excellent representative of an old one.

Most specimens of *Pholadomorpha pholadiformis* preserve the valves in a more or less compressed condition, owing to their preservation chiefly in clay shales or in very argillaceous limestones. The type of *Pholadomorpha capax*, however, is preserved in a fine grained limestone, and, apparently, retains its original convexity very well, as far as it is preserved at all. From this the following description is drawn.

The greatest thickness of the shell, or distance between the valves, occurs at mid-length, along the umbonal ridges. From this point the shell tapers both anteriorly and posteriorly. The thickest part of the shell is about 20 millimeters posterior to the beak, where it equals 20 millimeters. At the beaks, the thickness is reduced to about 14 millimeters. Forty millimeters posterior to the beak, the thickness still equals 19 millimeters, but posterior to the latter point the reduction in thickness is more rapid.

The umbones are strongly compressed and flattened, the flattening affecting practically all of the shell anterior so the umbonal ridge. Basal margin straight, mesial sulcus practically obsolete. Umbonal ridge rounded, only moderately distinct for a distance of 20 millimeters posterior to the beak along which the cardinal surface of the shell is more or less flattened horizontally. Posteriorly, the umbonal ridge becomes almost obsolete, being indicated by a slight flattening of the postumbonal slope. Posterior outline probably as in other specimens of *Pholadomorpha pholadiformis*.

A part of the original shell substance is preserved. The thickest part of the right valve is found in the area extending from the cardinal margin downward for a distance of 10 millimeters from a point 10 millimeters anterior to the beak, where the thickness is

about three-fourths of a millimeter, to a point 15 millimeters behind the beak, where the thickness equals about half a millimeter, excepting along the immediate vicinity of the hinge-line. Toward the basal margin, the thickness of the valve diminishes to scarcely more than a sixth or a seventh of a millimeter.

The shell is distinctly wrinkled concentrically, the wrinkles being quite strong anteriorly, from the umbonal area as far down as the basal margin, although not quite as distinct as in the umbonal region of *Sedgwickia divaricata* Hall and Whitfield.

Transverse, low, rounded plications, distinctly defined anteriorly, where the shell is preserved; less distinctly defined posteriorly, along the hinge-line, where the shell is partly exfoliated; almost invisible along the lower, posterior part of the internal cast of the right valve, where all of the shell substance is gone.

Faint, broad grooves radiate from the posterior side of the beaks along the post-umbonal slope, but are thought to have no special significance. Similar grooves are seen occasionally in *Modiolopsis*.

Additional information regarding the shell substance of *Pholadormorpha pholadiformis* is presented by a specimen collected by the writer in a limestone layer at the top of the Waynesville member of the Richmond, along Cowan creek, southeast of Clarksville, Ohio. The outer black coat of the shell is very thin, as thin as paper. This is the part which is preserved in the form of a thin black film in the fine-grained sandstones of the so-called Lorraine of New York, Canada, and Wisconsin. The remainder of the shell is much thicker, especially toward the umbonal region, where it reaches a thickness of about two-thirds of a millimeter. This part of the shell consists of vertical fibers, possible of aragonite, and this is the part which usually is not preserved, especially in argillaceous and arenaceous strata. Anteriorly, the concentric wrinkles are well marked. Posterior to the beak, both along the base and along the hinge-line, the transverse plications are well defined, extending toward the crest of the umbonal ridge.

43. **Pholadomorpha corrugata,** Miller and Faber

(Plate V, Fig 5)

1892. Modiolopsis corrugata Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., 15, p. 79, Plate 1, Fig. 1

The type of *Modiolopsis corrugata* forms No. 8813 in the Faber collection at Chicago University. It was described as coming from

near the top of the hills, in Cincinnati, but the museum label bears the legend, "Warren Co., Ohio," and the latter probably is the real origin. I know of no reason for regarding this type as of earlier age than the Waynesville member of the Richmond.

The type so evidently is merely a flattened specimen of *Pholadomorpha pholadiformis*, such as are characteristic of the soft clay shale deposits in the lower part of the Waynesville member of the Richmond, that it deserves no further comment. The figure presented by Miller and Faber is sufficiently accurate, but another figure is offered in the present Bulletin. The so-called posterior wing, mentioned in the original description, is merely the postumbonal slope. The low, broad, transverse plications along the posterior part of the cardinal margin are sufficiently distinct to suggest those of *Pholadomorpha divaricata*, as figured from the Rivere des Hurons in this Bulletin, in 1914.

44. **Pholadomorpha sulcata,** Miller and Faber

(Plate V, Fig. 2)

1892. Modiolopsis sulcata Miller and Faber, Jour. Cincinnati Soc. Nat. Hist.' 15, p. 79, Plate 1, Fig. 4

The type of *Modiolopsis sulcata*, numbered 8798, is preserved in the Faber collection at Chicago University. It was described as having been found on the hills at Cincinnati, Ohio; on the label, however, the words "Warren Co., Ohio" appear and the latter locality probably was the real origin. I know of no reason for regarding its horizon as having been below that of the Waynesville member of the Richmond.

It is so evident that the type is merely a vertically compressed specimen of *Pholadomorpha pholadiformis* that it is difficult to understand how the specimen came to be described at all. While the vertical diameter of the specimen has been diminished very much by compression, the cardinal view has not been altered greatly, so that from this point of view the flattened umbones, narrowly compressed, and the flattened cardinal slopes immediately posterior to the beaks are well exposed. The lanceolate widening of the shell toward midlength is well preserved. The radiating low broad grooves on the postumbonal slope, mentioned in the case of the interior cast of *Modiolopsis capax*, have been accentuated by the vertical compression, but the figure accompanying the original

description of *Modiolopsis sulcata* is greatly overdrawn. Not only the low transverse plications along the basal margin but also those along the posterior part of the cardinal margin can be detected.

Judging from other specimens of *Pholadomorpha pholadiformis*, one of the faint, broad, radiating grooves of the postumbonal area usually is located immediately above the crest of the umbonal ridge, and a second groove is found a short distance above the first. Additional grooves may occur nearer the hinge-line.

45. **Rhytimya cymbula,** Miller and Faber

(Plate VI, Figs. 8 A, B)

1894. Orthodesma cymbula Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., 17, p. 143, Plate 8, Figs. 7-9

The type of *Orthodesma cymbula* is numbered 8814 in the Faber collection at Chicago University. It was described as not very uncommon in the upper part of the Cincinnati series of rocks in Warren county, Ohio, but the type is labelled as coming from Cincinnati, Ohio. This type, undoubtedly, is identical specifically with *Rhytimya mickleboroughi* Whitfield, as figured by Ulrich in the Geology of Ohio, volume 7, from the Fairmount member of the Maysville group, a fact already indicated by Bassler in his Bibliographic Index of American Ordovician and Silurian Fossils.

The shell substance is very thin. Owing to the prominent umbonal ridges and the flattened dorsal slopes, the cross-section of the shell is strongly triangular. The dorsal flattening is conspicuous for a distance of about 35 mm. from the beaks, and the umbonal ridge makes an angle of about 15 degrees with the hinge-line. A distinct mesial depression extends from the beaks toward the middle of the ventral margin, broadening toward the latter, and forming a concave outline along the latter. Anterior to this depression the shell is swollen along a line forming an angle of about 70 degrees with the hinge-line. Between this part of the shell and the umbonal ridge there are obscure traces of radiating striations. The anterior part of the shell is almost acutely pointed. The upper posterior part of the shell, and the tip of the anterior part are not preserved. The characteristic wrinkles of *Rhytimya* are strongly developed anteriorly, are much less conspicuous within the area of the broad mesial depression, and are weakly defined on the postumbonal slopes.

46. **Vallatotheca manitoulini,** Foerste

(*Plate V, Fig. 6*)

1914. Vallatotheca manitoulini Foerste, Bull. Sci. Lab. Denison Univ., p. 482, Plate 4, Figs. 4 A, B)

The type, No. 8448 in the Victoria Memorial Museum, at Ottawa, Canada, was found in the Waynesville member of the Richmond at the Clay Cliff, about four miles south of the termination of Cape Smith, on the eastern shore of Manitoulin island, in Canada. In the present Bulletin, a figure, enlarged about three and a half diameters, is introduced in order to show the radiating striæ and the lamellose lines of growth of the shell. At each of these so-called lines of growth a single lamella curves upward and outward sufficiently to become free from the general surface of the shell for a short distance. The radiating striæ are not strictly continuous from one lamella to the next, each lamella representing a more or less distinct growth of the margin of the shell.

47. **Endoceras arcuatum,** J. F. James

1886. Colpoceras arcuatum, James, Jour. Cincinnati Soc. Nat. Hist., 8, p. 242, Plate 4, Figs. 1, 1a

The type of *Colpoceras arcuatum* should be present in the Museum of the Cincinnati Society of Natural History, but has been lost. According to the author of the species, specimens of the same species should occur in the U. P. James collection. Two specimens, labelled *Colpoceras arcuatum,* and found at Cincinnati, Ohio, are numbered 657 in the James collection at Chicago University. Of these only one shows the degree of tapering demanded by the figure of the type illustrated by James. This specimen is 125 mm. long, 32 mm. wide at the larger end, and 20 mm. wide at the smaller end. The specimen consists of a nearly smooth siphuncle, crossed by faint oblique markings indicating the lines of contact with the septa. Six cameras in a length of 58 mm. were present near the middle of the specimen, and possibly 12 cameras may formerly have been present in its entire length. Parasitic bryozoans are attached to the exterior of this siphuncle and it probably came from the lower part of the Maysville group at Cincinnati, Ohio.

The second specimen, bearing the same number, figure 10 on plate VI of this bulletin, tapers considerably less than the type and is regarded as belonging to a different species of *Endoceras.*

It is 60 mm. long, nearly cylindrical in form, 24 mm. wide, and has 5 cameras in a length of 40 mm. The oblique annulations, indicating lines of contact with the septa, form angles of 70 degrees with the longitudinal axis of the specimen.

A third specimen, numbered 401 in the James collection, found at Harman station in Indiana, and also labelled *Colpoceras arcuatum*, also differs from the type in being nearly cylindrical. It is 160 mm. long, 35 mm. wide at midlength, ten cameras occupy a length of 93 mm., and the lines of junction with the septa form angles of about 80 degrees with the longitudinal axis of the specimen.

48. **Caliculospongia pauper,** gen. et sp. nov.

(Plate VI, Figs. 9A, B, C)

Sponge small and short (13 mm. wide; 21 mm. long), with shallow cloacal cup (7 mm. wide and 3 mm. deep) and with relatively thick walls. Base apparently with short, blunt, subradiciform angulations. Entire sponge perforated by numerous tubular canals, about a quarter of a millimeter in diameter. Within the cup the canal openings tend toward arrangement in lines, chiefly horizontally, about 3 or 4 openings in a distance of 2 millimeters. On the exterior of the sponge no tendency toward linear arrangement is noticed. Under a lens, the surface of the sponge appears dense, and no spicular or fibrous structure is seen. The sponge material often is slightly raised along the margin of the canal openings. The canals often approach the surface very obliquely, and the surface of the sponge, therefore, appears marked by tortuous channels and intermediate ridges. The path of the canals, from the interior of the sponge toward its exterior, also is very irregular.

Found in the Millersburg member of the Cynthiana formation, along the Belt line of railroad, opposite the Magoffin estate, in the northeastern part of Lexington, Kentucky.

49. **Carneyella and Isorophus,** gen. nov.

Among the Ordovician species usually referred to the Devonian genus *Agelacrinites* it is possible to distinguish several groups, for two of which the terms *Carneyella* and *Isorophus* are here proposed. The type of *Carneyella* is *Agelacrinus pileus*, Hall, from the Maysville formation of Ohio, Indiana, and Kentucky. The type of *Isorophus* is *Agelacrinus cincinnatiensis*, Roemer, from the same

formation and area, extending its range into western Tennessee. In *Carneyella* the five plates occupying the interradial angles differ in form from the lateral covering-plates characterizing the rays; this is true especially of the two anterior and of the conspicuous posterior supra-oral plates (1872, Hall, 24th Rep. N. Y. St. Mus., pl. 6, figs. 8, 9; 1914, Foerste, Bull, Denison Univ., 17, pl. l, fig. 5B). In *Isorophus* the spura-oral plates differ only slightly from the lateral covering-plates of the rays, and the genus is regarded as more primitive in type. To *Isorophus* are referred *Agelacrinus cincinnatiensis*, Roemer, *Agelacrinus holbrooki*, James, and *Lebetodiscus inconditus*, Raymond. In all of these species accessory covering-plates are present along the median line of the rays. To *Carneyella* are referred *Agelacrinus pileus*, Hall, *Agelacrinus billingsi*, Chapman, *Lebetodiscus chapmani*, Raymond, *Lebetodiscus youngi*, Raymond, *Lebetodiscus platys*, Raymond, *Lebetodiscus multibrachiatus*, Raymond, and *Agelacrinus vetustus*, Foerste. None of these species possess accessory covering-plates along the median line of the rays. On that account it is suspected that *Agelacrinus austini*, Foerste, in which the supra-oral area is not distinctly preserved, will prove to belong to the *Isorophus* group.

In *Lebetodiscus dicksoni*, Billings, and *Lebetodiscus loriformis*, Raymond (1915, Raymond, Ottawa Naturalist, p. 53), all the rays are contra-solar. The supra-oral plates differ from the lateral covering plates of the arms merely in their smaller size. From the median ridge of the covering-plates short ridges extend off laterally, excepting at the tip of the plates, where the median ridge broadens out. There are no accessory plates along the median line of the rays.

The name *Carneyella* is proposed in recognition of the valuable contributions of Prof. Frank Carney to physical and glacial geology.

PLATE I.

Fig. 1. STROMATOCERIUM GRANULOSUM James (=Str. huronense Billings) ..... p 299
Type of Alveolites granulosus James, No. 2250, in the James collection at Chicago University. From the Waynesville member of the Richmond group, at Clarksville, Ohio.

Fig. 2. DERMATOSTROMA GLYPTUM Foerste ..... p 298
Type belonging to the collection of Dr. George M. Austin, of Wilmington, Ohio. From upper part of Whitewater member of Richmond group, on Dutch creek, northwest of Wilmington Ohio.

Fig. 3. DERMATOSTROMA PAPILLATUM James ..... p 297
Specimen growing on Byssonychia. From the Clarksville division of the Waynesville member of the Richmond group, at Clarksville, Ohio.

Fig. 4. DERMATOSTROMA SCABRUM James ..... p 297
Specimen growing on Byssonychia. From the Waynesville member of the Richmond group. Collection of Dr. George M. Austin, at Wilmington, Ohio.

PLATE I

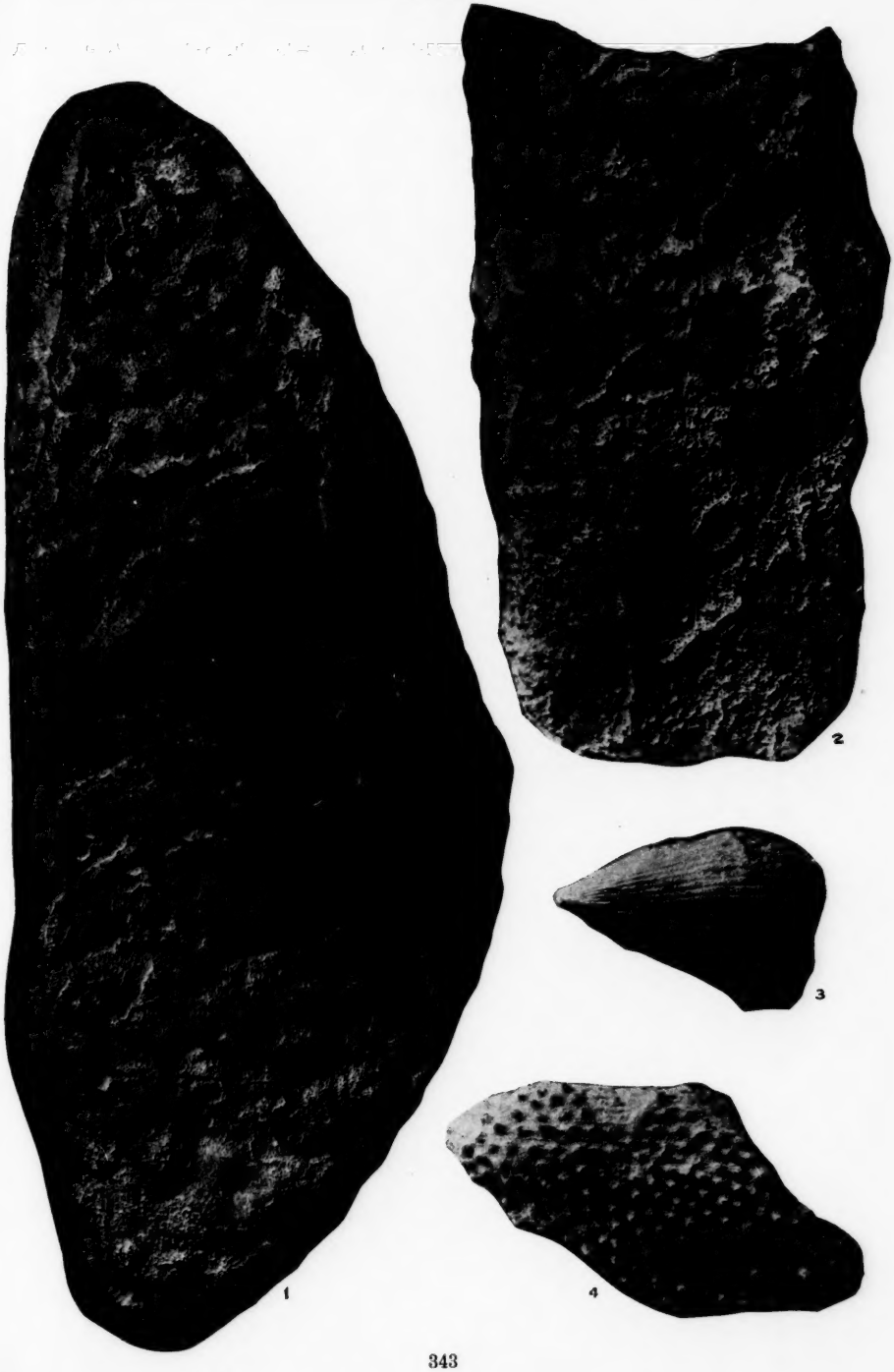


PLATE II.

Fig. 1. STROMATOCERIUM MONTIFERUM Ulrich (=Str. huronense Billings) ..... p 301

Type of Labechia montifera Ulrich, preserved in the collection of Geo. K. Greene, at New Albany, Indiana. From the Saluda member of the Richmond group, at Madison, Indiana.

Fig. 2. LEPTOPOTERION FABERI Miller (=L. mammiferum Ulrich) . p 291

Type of Chirospongia faberi Miller. A, natural size; B, one of the elevations enlarged. In this type, the short vertical striae, regarded as parts of spicules, are better preserved than indicated in the enlarged figure here presented. No. 8827, in the Faber collection at Chicago University. From the Corryville member of the Maysville group, at Cincinnati, Ohio.

Fig. 3. PROTARÆA VETUSTA Hall ..... p 292

Type of Porites ? vetusta Hall, No. 642, in the American Museum of Natural History, in New York City. From the base of the Trenton, at Watertown, New York.

PLATE III.

Fig. 1. PASCEOLUS TUMIDUS James (=P. darwini Miller) ..... p 287

Specimen showing stellate grooving of plates. One of the cotypes, No. 1222, in the James collection at Chicago University. Middle of Maysville group, at Cincinnati, Ohio.

Fig. 2. PASCEOLUS CLAUDEI Miller ..... p 287

One of the cotypes, No. 8837, in the Faber collection at Chicago University. Base of Bellevue member of Maysville group, at Maysville, Kentucky.

Fig. 3. DYSTACTOSPONGIA ? CAVERNOSA n. sp. ..... p 290

From Cincinnati, Ohio. Label lost, but probably from middle of the Maysville group.

Fig. 4. DYSTACTOSPONGIA MADISONENSIS Foerste ..... p 290

Specimen found seven feet above chief Columnaria bed at base of the Saluda member of the Richmond group, at Madison, Indiana.

Fig. 5. CALAPŒCIA CRIBRIFORMIS Nicholson (=C. huronensis) .... p 293

Type, No. 216, in the James collection at Chicago University. Probably from the Richmond group at some unknown locality in Ohio.

Fig. 6. LINGULA VANHORNEI Miller ..... p 306

Pedicel valve, partly exfoliated, showing the vascular branches anterior to the muscular area. Type, No. 8865, Faber collection at Chicago University. Lower Richmond, at Versailles, Indiana, probably from the Waynesville member.

PLATE II

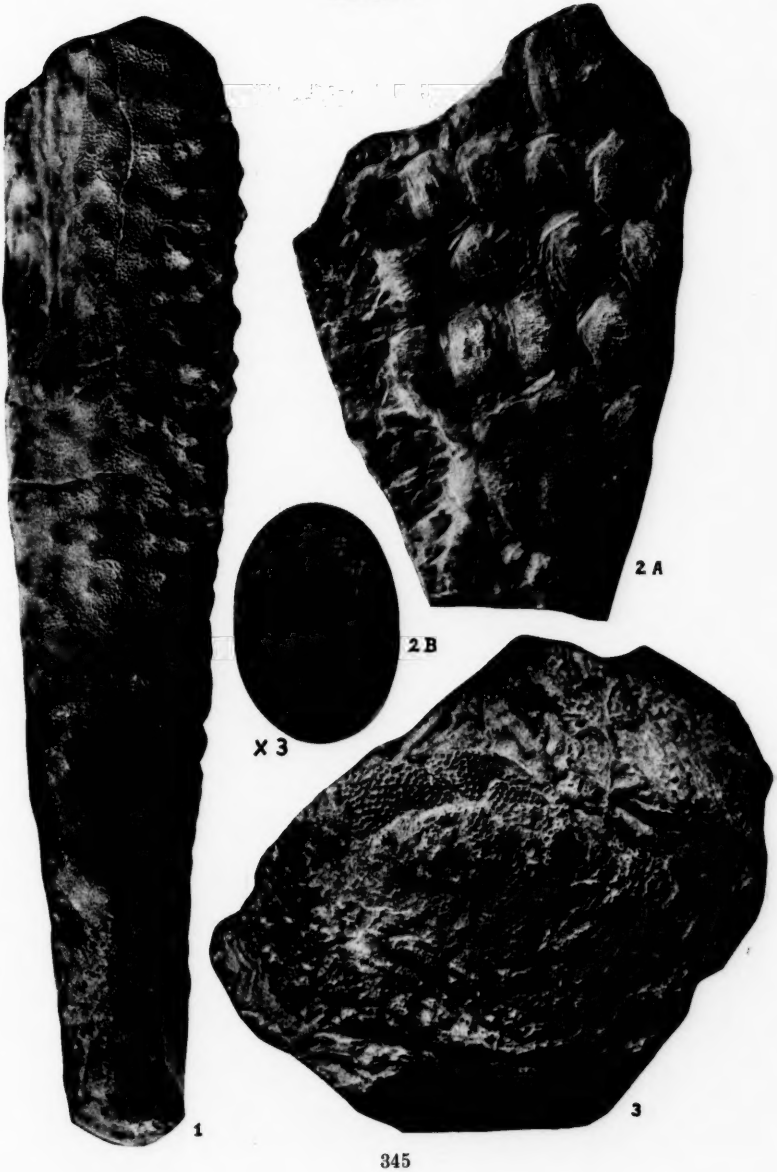


PLATE III.—Continued

Fig. 7. LINGULA COVINGTONENSIS Hall and Whitfield.....p 305
The lower left margin of this figure should be rounded like the margin on the right side. Type, No. 139, in the James collection at Chicago University. Figure, slightly enlarged, prepared from cast of more or less exfoliated interior of valve. Upper part of the Cynthiana group, at West Covington, Kentucky.

Fig. 8. CRANIA ALBERSI Miller and Faber.....p 322
A, enlarged 2 diameters; B, enlarged 4 diameter. Type, No. 8863, in the Faber collection at Chicago University. In the Economy member of the Eden group, at Cincinnati, Ohio.

Fig. 9. CRANIA ASPERULA James (=Cr. scabiosa Hall).....p 314
A, natural size, B, enlarged. Posterior margin along upper right hand margin of figure. Photographed obliquely so as to show the plications crossing the upper valve. Type in the Welch collection, in Wilmington college, at Wilmington, Ohio. Base of Liberty member of Richmond group, at Clarksville, Ohio.

Fig. 10. CRANIA ALTERNATA James (=Cr. scabiosa Hall).....p 315
A, natural size; B, enlarged. Type, No. 1557, James collection, Chicago University. Upper or Blanchester division of Waynesville member of Richmond group, at Blanchester, Ohio.

Fig. 11. CRANIA SOCIALIS Ulrich.....p 321
A, group attached to crinoid stem, natural size; B, enlarged. Typical specimen, No. 8868, in the Faber collection at Chicago University. Eden group, atCincinnati, Ohio.

Fig. 12. TREMATIS ? FRAGILIS Ulrich.....p 311
Specimen figured as Trematis punctostriata by Hall and Whitfield, Pal. Ohio, 2, 1873, pl. 1, Fig. 9 (not Tr. punctostriata Hall, 1873, from Clifton, Tennessee). No. 102, James collection. Chicago University. Probably from Eden group, Cincinnati, O.

Fig. 13. CRANIA MULTIPUNCTATA Miller (=Crania scabiosa Hall).p 313
A, natural size; B, enlarged. Type, No. 8869, in Faber collection at Chicago University. From the upper half of the Maysville group at Cincinnati, Ohio.

Fig. 14. TREMATIS FRAGILIS Ulrich.....p 311
Pedicel valve. Probably from the Eden group, Cincinnati, O.

Fig. 15. CRANIA COSTATA James (=Cr. scabiosa Hall).....p 314
Posterior margin, near lower left hand margin of figure. Photographed so as to show the plications on the upper valve. Type, in Welch collection, deposited in Wilmington college, at Wilmington, Ohio. Probably from some part of the Richmond group, near Clarksville or Wilmington, Ohio.

Fig. 16. TREMATIS FRAGILIS Ulrich.....p 311
Brachial valve, associated with pedicel valve, figure 14.

Fig. 17. LINGULOPS NORWOODI James.
Type of Lingula norwoodi James, No. 623, in James collection at Chicago University. A, slightly reduced; B, enlarged 2 diameeters. From the upper part of the Cynthiana formation at West Covington, Kentucky, opposite Cincinnati, Ohio.

PLATE III

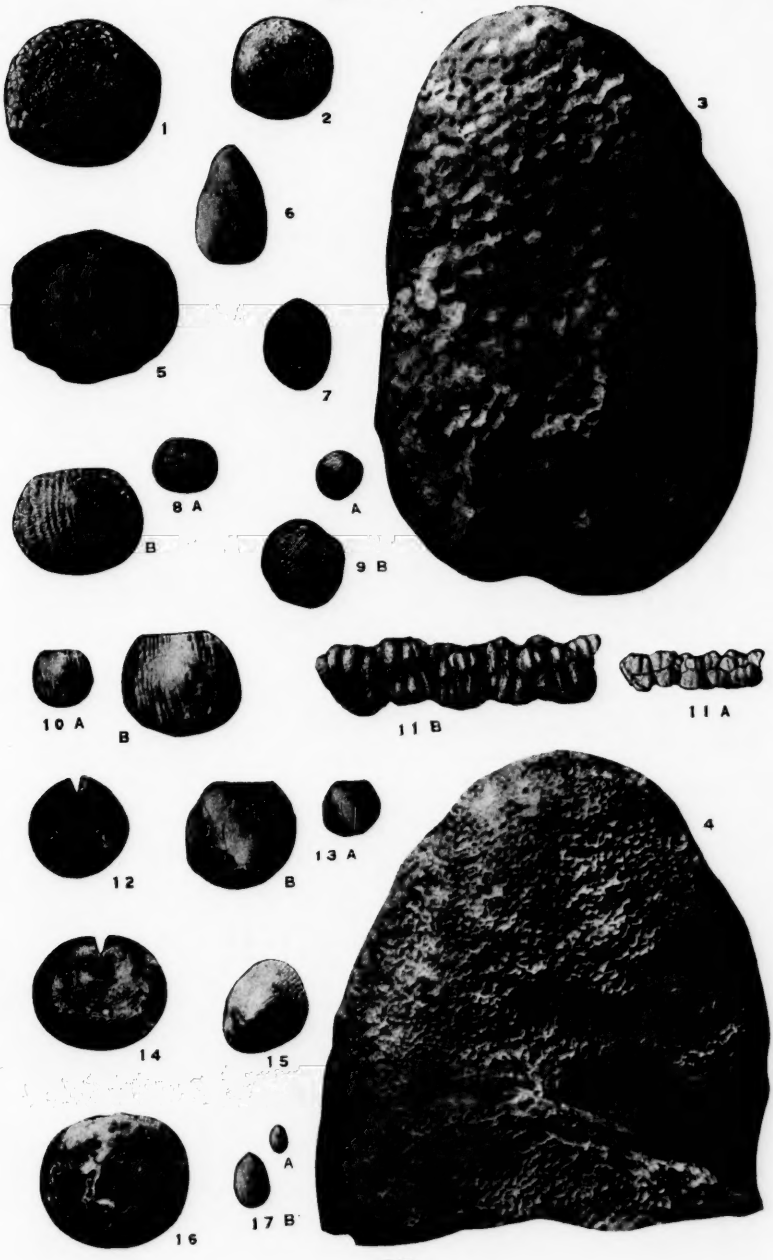


PLATE IV

Fig. 1. BYSSONYCHIA ROBUSTA Miller.....p 328
Type of Ambonychia robusta Miller, No. 8816, in the Faber collection at Chicago University. A, right valve, chiefly interior cast (=Fig. 3 accompanying original description). B, left valve of same specimen. C, anterior view of a second specimen (=Fig. 3a accompanying original description). Base of Saluda member of Richmond group, at Versailles, Indiana.

Fig. 2. ANOMALODONTA ALATA Meek.....p 326
Right valve. Waynesville member of Richmond group, on Clifty Fork, west of Madison, Indiana.

Fig. 3. ANOMALODONTA COSTATA Meek.....p 328
Type of Ambonychia costata Meek, No. 790, in the James collection at Chicago University. Left valve, with indication of posterior outline drawn from lines of growth on other specimens; the type exposes chiefly the cast of the interior. Possibly from the Arnheim member of the Richmond group at Cincinnati, Ohio, but the species ranges upward also into the Waynesville member of the Richmond.

Fig. 4. MODIOLOPSIS VERSAILLESENSIS Miller.....p 331
Left valve, No. 8791, in Faber collection at Chicago University (=Fig. 18 accompanying original description). Waynesville member of the Richmond group, at Versailles, Indiana.

Fig. 5. LINGULA VANHORNEI Miller.....p 306
Type, No. 8865, In the Faber collection at Chicago University. Largely exfoliated, showing parts of interior. A, pedicel valve, with shell retained toward beak and along right margin. B, brachial valve, with shell retained toward beak and along left half. Both figures magnified 3 diameters and retouched so as to accentuate the details of the interior markings. C, vertical outline of shell. Waynesville member of the Richmond group at Versailles, Indiana.

Fig. 6. LINGULA BROOKVILLENSIS nov. sp.....p 308
A, pedicel valve; B, brachial valve. Both figures magnified 3 diameters, and retouched so as to accentuate the details of the interior markings. C, vertical outline of shell. Found at Boundary Hill, along railroad, two miles west of Brookville, Indiana. Probably from the Arnheim member of the Richmond group.

Fig. 7. CRANIA PERCARINATA Ulrich.....p 317
Enlargment of part of the striæ crossing the upper valve of Crania percarinata, in order to indicate the former attachment of this type to the peripheral border of a Lophospira. Same specimen as that figured on plate VI of this bulletin.

PLATE IV

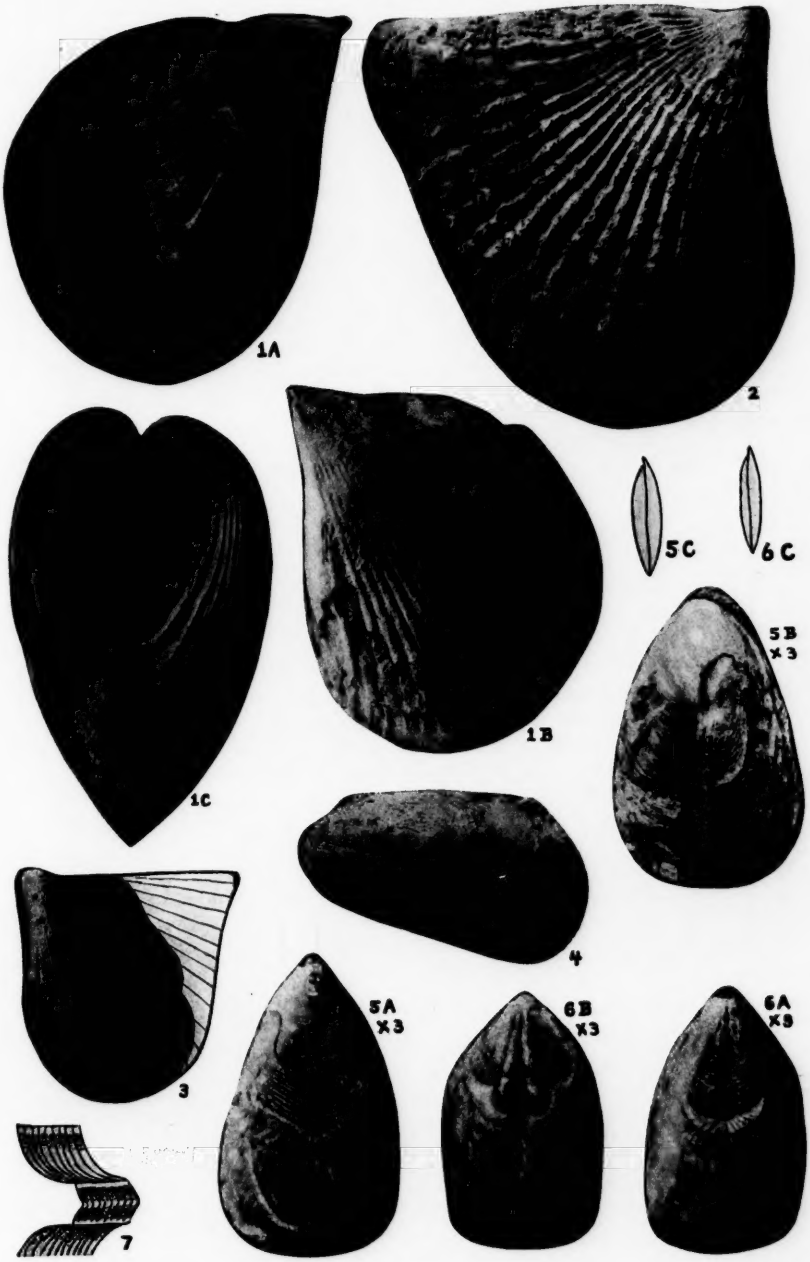


PLATE V

Fig. 1. MODIOLOPSIS BREVANTICA n. sp ..... p 332

A, cardinal view; B, left valve. Type. From the Waynesville member of the Richmond group at Clay Cliff, 4 miles south of the end of Cape Smith, on the eastern shore of Manitoulin Island, Ontario.

Fig. 2. PHOLADOMORPHA SULCATA Miller and Faber (=Ph. pholadiformis Hall) ..... p 337

Left valve, with several longitudinal folds due to oblique compression within soft shale. Type of Modiolopsis sulcata, No. 8798, in the Faber collection at Chicago University. Labelled as coming from Warren county, Ohio. Probably from the Richmond group.

Fig. 3. PHOLADOMORPHA DIVARICATA Hall and Whitfield (=Ph. pholadiformis Hall) ..... p 333

A, left valve; B, cardinal view; C, right valve enlarged. Type of Sedgwickia divaricata, No. 1489, in the James collection at Chicago University. From the upper or Blanchester division of the Waynesville member of the Richmond group, at Blanchester, Ohio.

Fig. 4. PHOLADOMORPHA CAPAX Miller (=Ph. pholadiformis Hall) p 334

A, right valve; B, cardinal view, with anterior end toward the upper part of the figure. Type of Modiolopsis capax, No. 8802, in the Faber collection at Chicago University. From Versailles, Indiana. Probably from the Waynesville member of the Richmond group.

Fig. 5. PHOLADOMORPHA CORRUGATA Miller and Faber (=Ph. pholadiformis Hall) ..... p 336

Left valve. Type of Modiolopsis corrugata, No. 8813, in the Faber collection at Chicago University. Labelled as coming from Warren county, Ohio. Probably from the Waynesville member of the Richmond.

Fig. 6. VALLATOTHECA MANITOULINI Foerste ..... p 339

Oblique view, with apex toward the lower right hand corner of the figure. Photographed so as to show the concentric lamellose outgrowths of the shell, and the short longitudinally directed striæ, terminating at the free margins of the lamellæ. Magnified about 3.5 diameters. Type, From the Waynesville member of the Richmond group, at Clay Cliff, on the eastern shore of Manitoulin island.

PLATE V

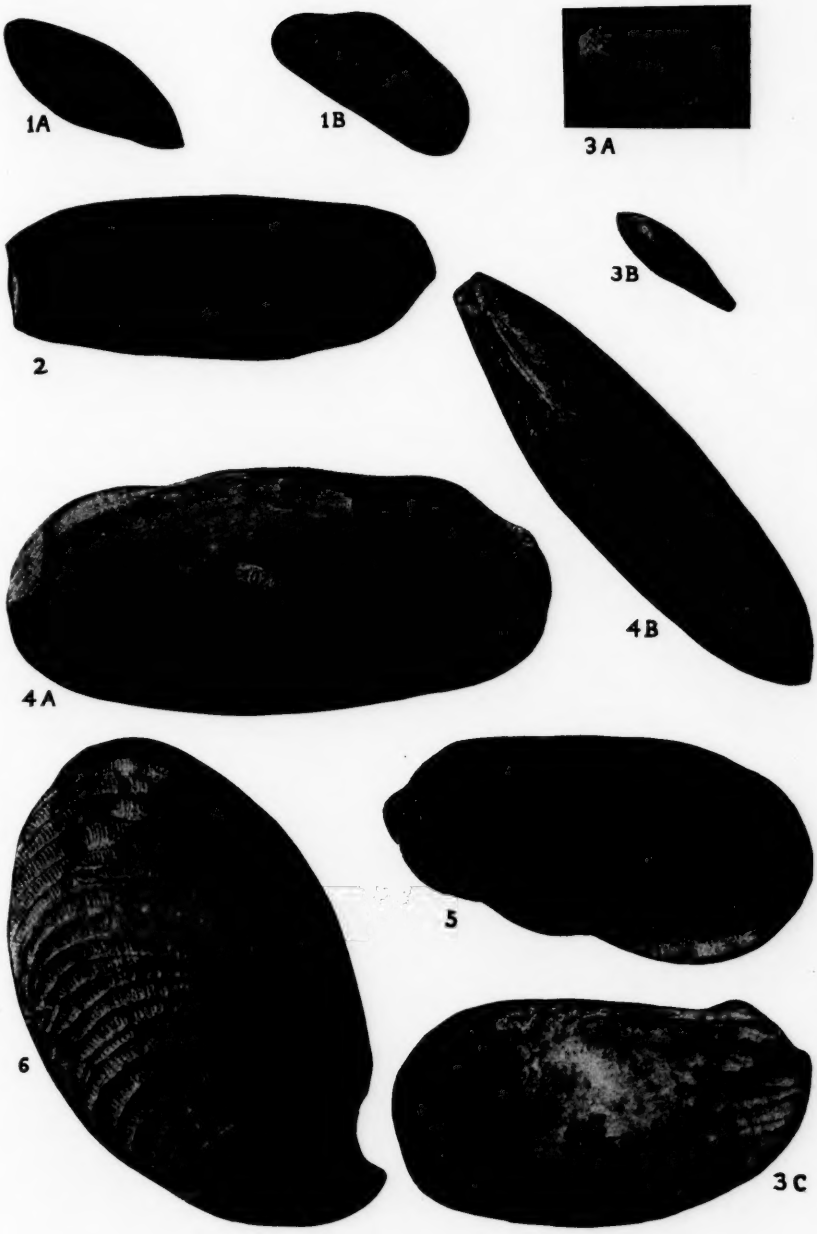


Plate VI

Fig. 1. CRANIA PERCARINATA Ulrich.....p 317
Type, magnified 3 diameters, in collection of Prof. Charles Schuchert, of Yale University. Reproducing markings of tricarinate peripheral band of Lophospira (See plate IV of this bulletin). Position of figure inverted from that shown in figure 30 on plate 4H, in volume VIII, of the paleontology of New York. From the Economy member of the Eden group, at Covington, Ky.

Fig. 2. CRANIA PARALLELA Ulrich.....p 319
Type, magnified 3 diameters, in collection of Prof. Charles Schuchert, of Yale University. Reproducing markings of Conularia. Specimen with margin broken off along upper part of figure. Economy member of Eden group, at Covington, Ky.

Fig. 3. CRANIA PARALLELA Ulrich.....p 319
One of the series of types in the collection of Prof. Charles Schuchert of Yale University. Specimen not figured heretofore, magnified 3 diameters. This specimen reproduces the markings of some shell, possibly the interior markings of a brachial valve of Plectambonites. In addition to this, the surface is marked by numerous short radiating striæ, too minute to be reproduced in the figure. Economy member, Eden group at Covington, Ky.

Fig. 4. CRANIA SOCIALIS Ulrich.....p 321
Type figured by Ulrich, magnified 3 diameters, in the collection of Prof. Charles Schuchert of Yale University. Reproducing outlines of the columnals of a crinoid stem. From lower half of Eden group, in the vicinity of Cincinnati, Ohio.

Fig. 5. TREMATIS PUNCTOSTRIATA Hall.....p 312
Upper valve, enlarged 2 diameters (=Fig. 1, on pl. V, of vol. XVI, of this bulletin). From the Saltillo member of the Trenton group, at the type locality, Clifton, Tennessee.

Fig. 6. TREMATIS CRASSIPUNCTATA Ulrich.....p 311
Type, magnified 3 diameters, in collection of Prof. Charles Schuchert of Yale University. From Fairmount member of Maysville group, at Cincinnati, Ohio.

Fig. 7. CYMATONOTA CYLINDRICA Miller and Faber (=C. typicalis Ulrich).....p 330
Type of Orthodesma cylindricum, No. 8801 in the Faber collection at Chicago University. A, left valve; B, dorsal view, showing oblique plications along the hinge-line. Probably from the Waynesville member of the Richmond group in Warren county, Ohio.

Fig. 8. RHYTIMYA CYMBULA Miller and Faber (=Rh. mickleboroughi Whitfield).....p 338
Type of Orthodesma cymbula, No. 8814, in the Faber collection at Chicago University. Defective at anterior and posterior extremities. A, left valve; B, dorsal view. From the Fairmount member of the Maysville group at Cincinnati, Ohio.

PLATE VI

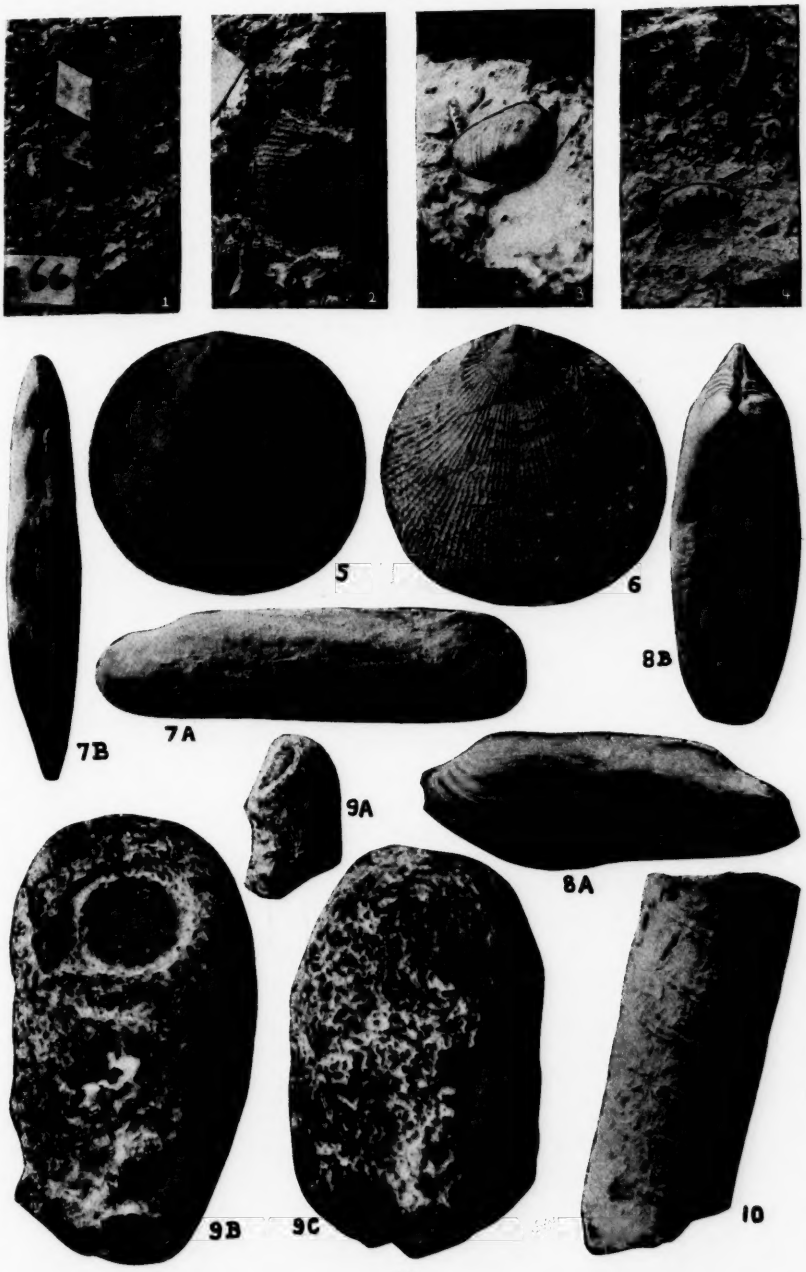


Fig. 9. CALICULOSPONGIA PAUPER gen. et sp. nov. ..... p 348

A, natural size, with cloacal cup at top seen diagonally from the side; B, same, with cloacal cup seen from the front, enlarged 3 diameters; C, same, viewed from the opposite side, showing the tortuous canals, enlarged 3 diameters. From the upper part of the Trenton group, along the belt line railroad at the Magoffin place, in Lexington, Kentucky.

Fig. 10. ENDOCERAS sp. ..... p 339

One of two specimens labelled Colpoceras arcuatum in the James collection at Chicago University and numbered 657. This specimen evidently is a siphuncle which tapers so much less than the type described by James that it must belong to a different species. The type of Colpoceras arcuatum also consisted of a siphuncle of some species of Endoceras. From the lower part of the Maysville group, at Cincinnati, Ohio.

PLATE VII

Fig. 1. WHITELLA CUNEIFORMIS Miller ..... p 323

Type of Orthodesma and Sphenolium cuneiforme Miller, No. 8803, in the Faber collection at Chicago University. A, right valve, imperfect, especially along the anterior and posterior margins; B, same, dorsal view; c, an attempt at a restoration of the original form of the type. Versailles, Indiana, probably from the Waynesville member of the Richmond group.

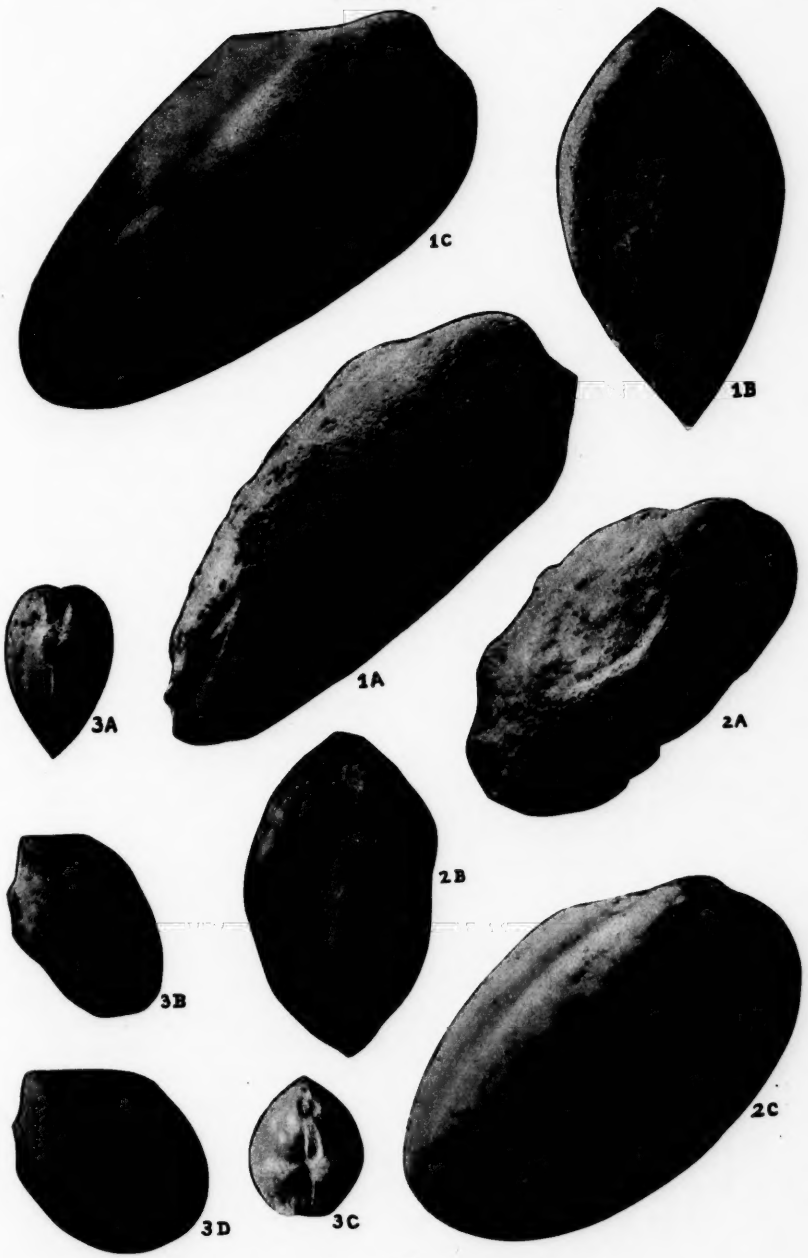
Fig. 2. WHITELLA RICHMONDENSIS Miller ..... p 324

Type of Sphenolium richmondense Miller, No. 8800, in the Faber collection at Chicago University. Imperfect, especially posteriorly. A, right valve; B, same specimen, dorsal view; C, an attempt at a restoration of the original form of the type. Richmond, Indiana, probably from the Whitewater member of the Richmond group.

Fig. 3. CYRTODONTA CUNEATA Miller ..... p 326

Type of Angellum cuneatum Miller, No. 8815, in the Faber collection at Chicago University. Imperfect, and artificially carved so that it may never be possible to identify the species. Especially imperfect along the anterior and posterior margins. A, anterior view; B, lateral view; C, dorsal view; D, an attempt at a restoration of the original form of the type, excepting at at the anterior extremity. Richmond, Indiana, probably from the Whitewater member of the Richmond group.

PLATE VII



THE SHORELINES OF GLACIAL LAKES LUNDY, WAYNE, AND ARKONA, OF THE OBERLIN QUADRANGLE, OHIO[1]

FRANK CARNEY

Six years ago in this Bulletin, vol. 16, pp. 101-117, the writer published a map of, and described, the glacial lake shorelines of the Oberlin quadrangle. Some of the beaches mapped were of doubtful interpretation, being too high or too low to conform to the shorelines then well-understood. The presence of other fragmentary beaches was not suspected, and accordingly not investigated.

During the past year, parts of this area have been re-visited, and other parts studied, in the light of progress made elsewhere in mapping the shorelines of former glacial lakes. So many corrections and alterations have been made that it is advisable to publish a new map.

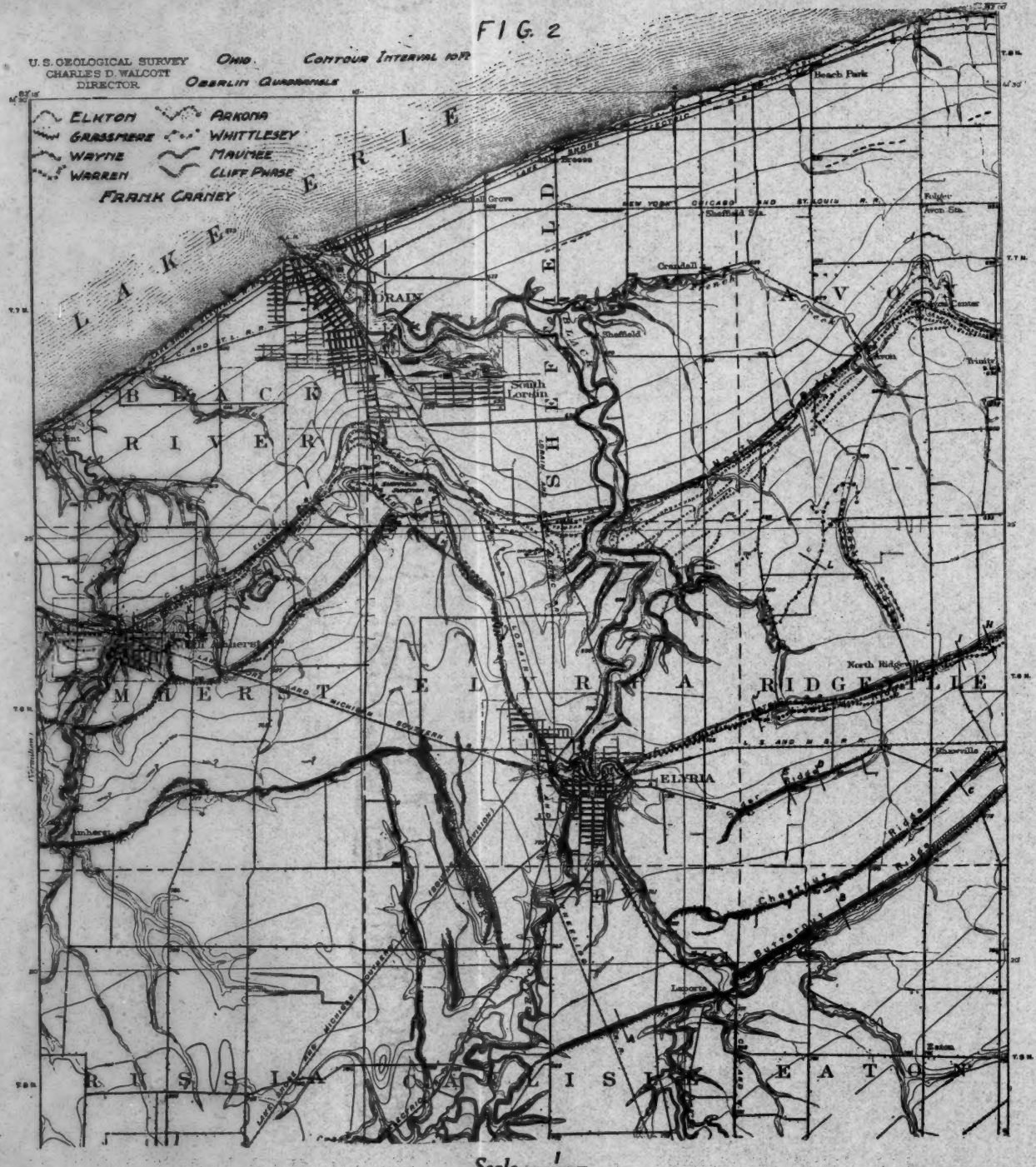
In a later issue of this Bulletin, a brief résumé of proglacial lake history was published (vol. 17, 1913, pp. 234-236); certain alterations are required in this résumé, chiefly thru the work of Leverett and Taylor (Monograph 53, U. S. Geol. Survey, 1915) who have ascertained more precisely the positions and altitudes of the outlets of the ice-front lakes, and the oscillations of the glacier margin associated with the several lake stages. The alterations required are principally in giving a wider range of altitude to the various lake stages; these are shown in Fig. 1 in which the submerged shorelines are indicated by broken lines.

Each retreat of the glacier was apt to uncover a lower outlet for the water ponded in front of the ice, resulting in a drop of the lake level, as when the glacier in the Huron basin withdrew far enough to uncover an outlet across the "thumb" of Michigan (the land between Saginaw Bay and Lake Huron), the first Lake Maumee, which overflowed by way of Fort Wayne, Ind., ceased to exist, and the lowest Maumee stage was formed. Later the ice readvanced, covering the outlet of the lowest Maumee and causing the water to rise over the shoreline which that lake stage had developed, thus inaugurating the lake which produced the "middle" Maumee shoreline. During the existence of this stage, the beach previously made stood beneath

[1]Published with the permission of the Geological Survey of Ohio.

Scale 1/12,000

FIG. 2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ELYRIA
RIDGEVILLE
SHEFFIELD
AVON
LORAIN
South Lorain
Sheffield
Grandall
Beach Park
North Ridgeville
Shawville
Trinity
Lagrange
Amherst
Russia
Eaton
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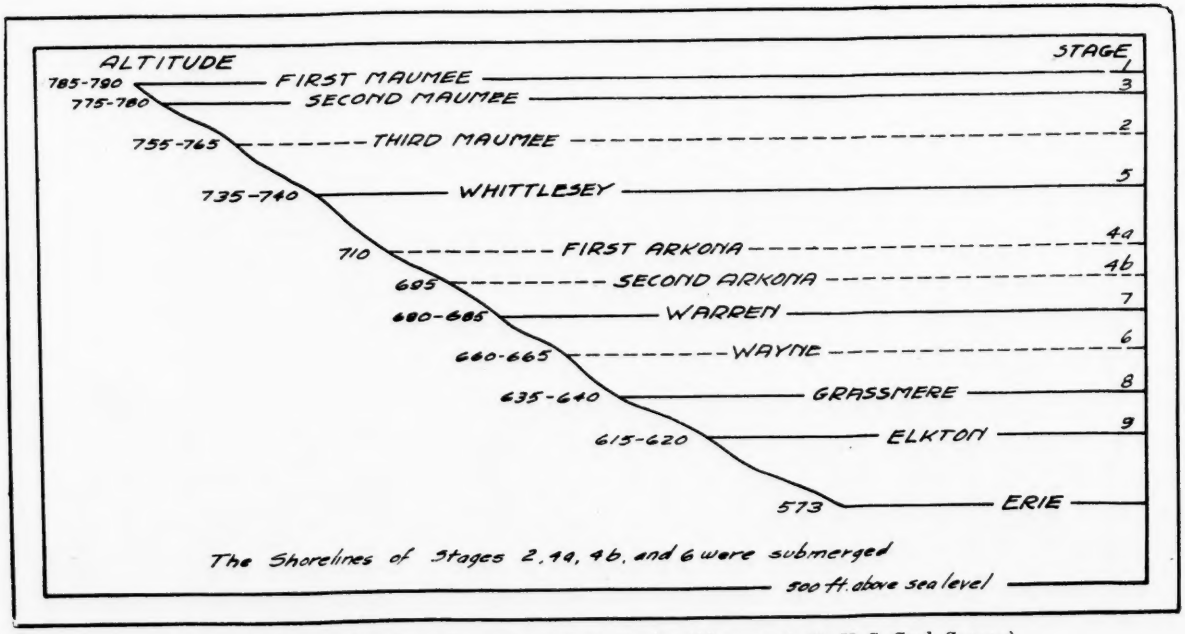


Fig. 1. Altitudes are based on the work of F. B. Taylor (Monograph 53, U. S. Geol. Survey).

water and was altered in several ways: (1) in some localities it was eroded by waves and currents, becoming fragmentary instead of being nearly continuous as abandoned beaches usually are; elsewhere it was washed down and flattened in cross-section; (2) the covering of water protected the beach from some phases of weathering, but emphasized others; (3) the water from the melting glacier contained much clay which filtered into the submerged beach and made it "stiffer and more firm than the ordinary beach soil."

The "middle" of the three Maumee stages was terminated by a retreat of the glacier; then the lake, lowered by about 70 feet, began to escape thru a depression near Maple Rapids, Mich. (Taylor, Monograph 53, p. 363), initiating Lake Arkona. Another readvance of the ice closed the Maple Rapids outlet and the level of the water was raised about 35 feet, forming Lake Whittlesey, and submerging the Arkona beaches. Again the glacier front withdrew and Lake Wayne came into existence. Lake Warren was the next in the series; this stage resulted from a forward movement of the ice, closing the Wayne overflow channel and submerging the Wayne shoreline. Then the glacier front must have remained fairly stationary for a long time, as the Warren shoreline has a strong development. The next retreat of the ice margin uncovered an outlet about 50 feet lower in altitude, and Lake Lundy was established, the lowest of the lake stages which may be seen in Ohio.

Lake Lundy

Elkton Stage. A few segments of this shoreline have been indicated on the Oberlin quadrangle. Proceeding westward from the east side of the sheet, the first segment, about 15 rods long, is met half way between Avon Station and the Lake Shore Electric Railroad. After a gap of one-half mile the beach reappears about three-fourths of a mile northwest of Avon Station, as a broad ridge, in places six or seven feet high, of fine gravel and sand. About two miles west of Sheffield Station is another remnant of this shoreline, shorter and less distinct. Careful study of the area between this and the Black River, as well as west of the Black River, did not show any further beach structures. At the proper horizon for the Elkton shoreline the ground moraine bears a conspicuous number of bowlders which generally rest almost directly upon the Erie shale. The general levelness of the area, together with the relatively short duration of

this lake stage, probably account for the scanty shoreline development.

Grassmere Stage. About one-quarter of a mile south of Avon Station, a low sandy ridge, approximately 80 rods in length, is the only beach structure, belonging to this stage, found east of the Black River. Coincident approximately with the correct altitude for this shoreline, the clay of the till has been removed, concentrating the bowlders. Between Black River and North Amherst the fields show a sandy soil, but nowhere was a beach form noted. West of Beaver Creek, commencing near its bank, a broad low sandy ridge, about 100 rods in length, crossed by the first north-south highway west of North Amherst, is the last evidence of the Grassmere shoreline noted on this quadrangle. The conditions suggested above for the slight development of the Elkton shoreline probably hold also in the case of the Grassmere.

Lake Wayne

Commencing on the east side of the Oberlin quadrangle this stage is marked by a low sandy beach as far west as Avon. North of Avon Center, the northernmost of the beaches which are associated with the cuspate foreland, belongs to Lake Wayne; the margin of this foreland has been subject to wave-erosion, as shown by the fact

Fig. 3. Bowlder strewn area along the Wayne shoreline northeast of Avon Center.

that the Berea sandstone for three-eighths of a mile is quite bare, and the fields contain numerous glacial boulders (Fig. 2). Between French Creek and Black River the shoreline consists mostly of a cliff cut in the fissile shale. Lying a few rods north of the front of this

cliff, barrier sand formed a lagoon, and, as a result, the fields contain a long narrow strip of muck soil paralleling the shoreline.

For about one-half mile west of Black River the cliff phase continues. This is succeeded by a very distinct sandy beach, in places rising five feet above the bordering plain. Approaching the Wheeling Railroad, the Wayne beach bears northward and continues as a deposit of sand. About 60 rods north of the point where the railroad crosses the shoreline, a steep slope in the rock marks its horizon; this condition persists for nearly 100 rods, when the shoreline again becomes a beach. South of Lorain the cuspate foreland of Lake Warren is bordered by a cliff cut in the Berea sandstone; several segments of beach, barrier structures of the Warren stage, mark the top slope of this cliff.

Westward of the foreland, structural deposits again indicate the Wayne level. With the exception of a few segments, however, this shoreline, beyond the point where it is intersected by the electric railroad, consists of a cliff; further evidence of wave-work is seen in the band of bowlders which parallels the cliff; west of Beaver Creek, for about one-third of a mile, the Lake Shore Railroad parallels the beach deposits of the Wayne stage. The last one-quarter of a mile on the sheet consists of a cliff cut in the Berea sandstone.

Lake Arkona

South of Trinity, just beyond the angle in the highway, a few rods of ridged sand and gravel may indicate the 695-foot stage of Lake Arkona. For a little over a mile directly west, the fields do not give any definite shoreline evidence. Commencing a short distance west of the highway which runs south from the North Ridge one and one-half miles west of Avon an indistinct sandy gravel-ridge, lying somewhat above the 690-foot contour, may be traced quite continuously to the Black River; for a part of this distance there are two low ridges about 40 rods apart.

On the west border of the bay which occupied the Black River valley depression more definite evidence of this stage was noted. Near the north boundary of Elyria township, between the Lorain and Elyria Electric R. R., and the Cleveland, Lorain and Wheeling R. R., the countours bend to the east around an outlier of Berea sandstone; from this outlier a spit grew southeastward, and is cut thru by the electric line; north of the outlier an accumulation of sand extends for about three-fourths of a mile; thence through a half-mile interval the fields show much sandy gravel, but no ridge.

The steepened slope just north of Sheffield Junction may represent wave-work of Lake Arkona. North of the quarry, marked on the map one mile east of North Amherst, the lower Arkona is probably indicated by an accumulation of sand piled against the flank of this outlier. In the vicinity of North Amherst the fields are sandy at this horizon but no beach exists. West of the Beaver Creek a sand beach, approximately one-third of a mile long, marks this shoreline.

The 710-foot stage of Lake Arkona is registered on either flank of Rocky Ridge which is traversed by the highway extending north from North Ridgeville. For about one-third of a mile, paralleling the southern end of this ridge, a fine gravel beach is indicated. Elsewhere on the east flank, a bare slope of rock registers the Arkona wave-work. On the coast of Lake Arkona this ridge formed a cape, the lake end of which is marked by a broad accumulation of sandy gravel which lies athwart the highway. On the west side of the cape's crest is a beach ridge extending nearly its entire length; this ridge may be the result of storm waves, as the cape was exposed to the west winds. The western border of this cape, save for a few rods near its north end, is indicated by an uninterrupted stretch of beach which terminates near a tributary of the Black River; at location L (Fig. 2) the front slope rises seven feet in a horizontal distance of 200 feet, and the back slope drops three feet. Between this tributary and Elyria no definite evidence of the Arkona was found.

West of the Black River, north of Elyria, a belt of sand at about the proper horizon probably represents the shoreline of this Arkona stage; thence for one mile the only evidence is the thinness of the drift; a clear cut beach deposit extends for about 100 rods south from the Berea outlier mentioned in an earlier paragraph. Just south of the angle in the highway, a mile directly east of Sheffield Junction, is a one-quarter mile stretch of beach. A short distance north of Sheffield Junction, a strongly developed ridge crosses the highway and terminates in a hook about 80 rods to the west. South of the ridge a swamp existed till drained a few years ago. Mr. Delano who owns the farm says it was necessary to dig a ditch 12 feet deep thru the ridge which was very coarse in texture, but at the bottom was sand, "as fine sand as you can find on the lake shore today." Between this point and North Amherst only a few segments of the shoreline were noticed. West of Beaver Creek the higher Arkona level is marked by a sandy condition of the fields, but no beach or cliff.

THE ABANDONED SHORELINES OF THE ASHTABULA QUADRANGLE, OHIO[1]

FRANK CARNEY

The southern border of the pro-glacial lakes on the Ashtabula Quadrangle was limited by the Painesville moraine. In northern Ohio the distribution and direction of the moraines has also influenced the course taken by many rivers; the Grand River, for example, for several miles flows along the outer border of the Painesville moraine.[2] In this quadrangle the lake plain is from three to five miles wide; the shorelines which cross it are roughly parallel; its surface is trenched by only one river, the Ashtabula, which rises south of the moraine; Wheeler, Cowles and Indian creeks, and Red Brook, have their sources in the moraine; except in their headwater sections, all these streams have low gradients.

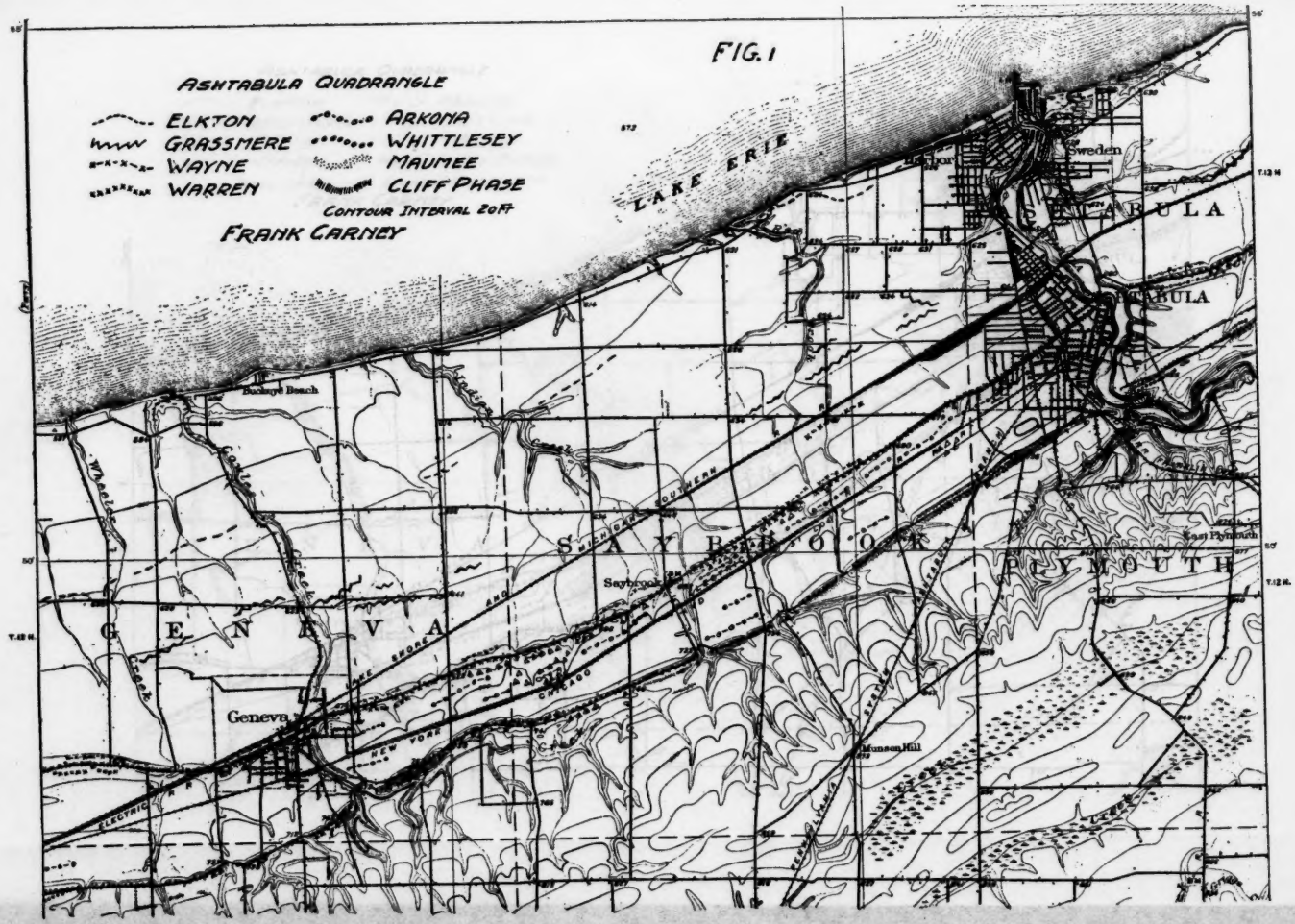
LAKE MAUMEE

One stage of Lake Maumee is registered across the Ashtabula Quadrangle by a disconnected series of gravel ridges and accumulations of sand. Commencing near the west border of the sheet (Fig. 1) where the north slope of the moraine is low, one notes, about two miles southwest of Geneva, a gravel ridge crossed by the first north-south highway on the sheet; laterally this ridge changes to a cut-bank; its strong development, however, appears to be responsible for the location of a house which stands many rods off the highway. The next two north-south roads to the east also cross slightly ridged gravel suggesting wave origin; the easternmost of these two deposits, that is, the one directly south of Geneva, bears more gravel on its south slope, whereas its top and its north slope in no wise differ from the water-laid materials that frequently characterize moraines.

Southeast of Geneva the top of the slope against which the Whittlesey shoreline is registered, frequently bears gravel belonging to Lake Maumee. A little farther east it seems probable that the dune sand, as shown in Fig. 2, is associated with this lake stage. Directly south of Saybrook, Maumee gravel lies immediately south of

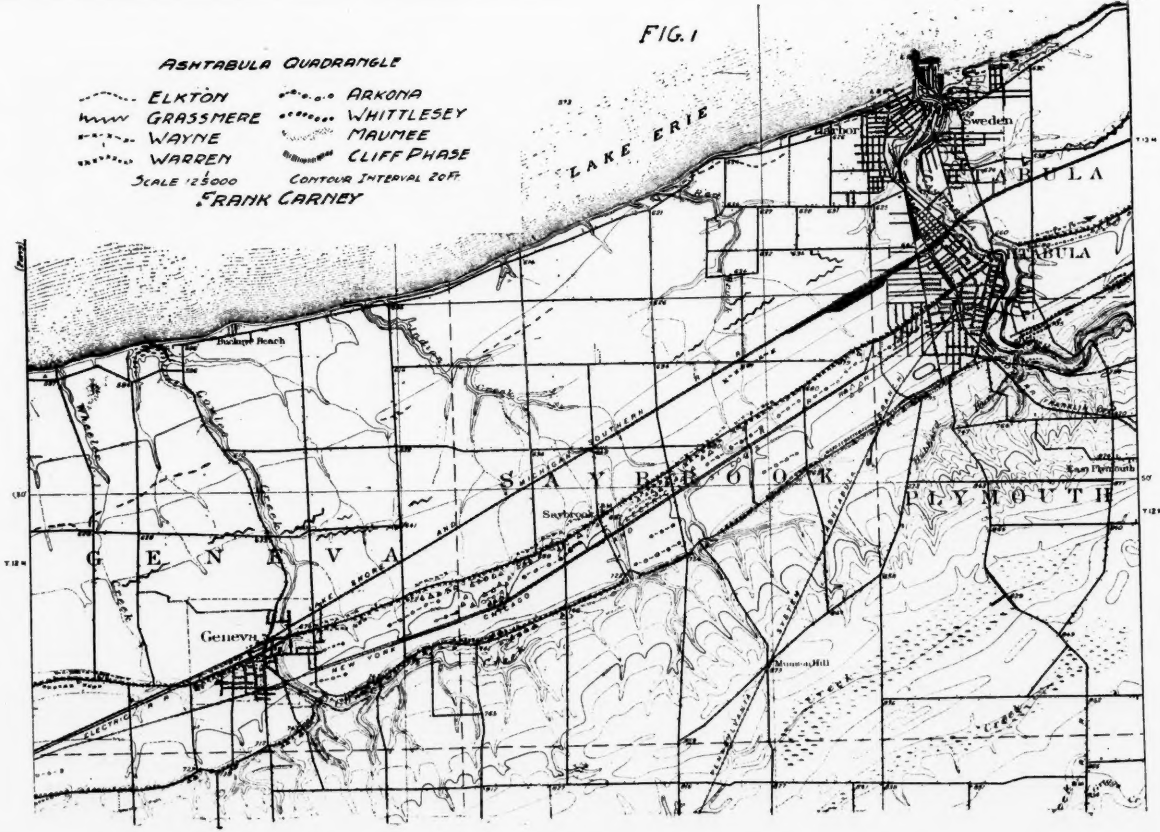
[1]Published by permission of the Geological Survey of Ohio.
[2]Frank Leverett, Monograph XLI, U. S. Geol. Survey, 1902, p. 652.

FIG. 1



Scale $\frac{1}{100,000}$

FIG. 1


ASHTABULA QUADRANGLE
ELKTON
GRASSMERE
WAYNE
WARREN
ARKONA
WHITTLESEY
MAUMEE
CLIFF PHASE
SCALE 1/125000
CONTOUR INTERVAL 20 FT.
FRANK CARNEY
LAKE ERIE
Harbor
Sweden
ASHTABULA
Buckeye Beach
SAYBROOK
Saybrook
PLYMOUTH
East Plymouth
GENEVA
Geneva
Mount Hill
Wheeler
Cowles Creek
Indian Creek
MICHIGAN SOUTHERN
LAKE SHORE AND
NEW YORK
CHICAGO
ELECTRIC R.R.
PENNSYLVANIA SYSTEM

the highway; an earlier position of Maumee wave-work is seen in a typically developed ridge about 20 rods farther south. Proceeding eastward, the top of the wave-cut Whittlesey slope bears Maumee sand and gravel continuously to the Ashtabula River. On the east side of the river no evidence of this shoreline is seen until within a few rods of the margin of the sheet, where we find a stretch of shore gravel about an eighth of a mile long.

These segments of the Maumee shoreline range about the 760-foot contour. In places where the sand has been drifted into knolls higher elevations are reached, even 800 feet, as southwest of Ashtabula; the location of such sand is indicated on the map (Fig. 1) by small triangles. Along modern as well as ancient shorelines sand is

Fig. 2. Whittlesey shoreline southeast of Geneva. The irregular sky line is due to knolls of wind-drifted sand belonging to the Maumee beach.

frequently found in knolls or dunes reaching 20 feet, and occasionally 100 or more feet, higher than the general level of that particular water stage. For this reason, the beaches above described may appear in places to indicate a higher Maumee shoreline; the possibility of erroneous interpretation here, because of drifted sand, has been pointed out by Leverett.[3]

Lake Whittlesey

On the Ashtabula sheet the Whittlesey shoreline, about 740 feet in altitude, is a conspicuous topographic feature. It has been sectioned by Cowles Creek a short distance south of Geneva, and by the Ashtabula River in the southern portion of the village of Ashtabula. Its water slope ranges from 10 to 40 feet in height; the back slope of

[3] *Ibid.*, p. 736.

the beach phases of the shoreline is four to eight feet high; locally the shoreline is a cliff cut in the moraine.

In the vicinity of Unionville on the Perry Quadrangle, which is next west of this sheet, the Whittlesey shoreline consists of two beach ridges, both of which continue a short distance eastward into the Ashtabula sheet. For the next mile a beach ridge, consisting of gravel and some fine sand, with a steepened outer slope, marks this shoreline. Where the highway which follows the Whittlesey crosses the east branch of Wheeler Creek, 15½ feet of glacial till is shown in the cut; the steepened slope in the drift becomes more conspicuous eastward toward Cowles Creek. Dunes cap the land slope for a mile west of this creek, and drifted sand is found continuously to the east as far as the meridian of Saybrook; these deposits of sand, as already described, belong to Lake Maumee.

From a point three and one-half miles west of the Ashtabula river the cliff phase of the Whittlesey continues to the river; throughout most of the last two miles, the outer slope is often 40 feet high, as shown in Fig. 3. In the absence of cuts it could not be determined whether rock forms any part of this cliff; the till in the area is probably over 40 feet thick; the Ashtabula branch of the Pennsylvania railroad makes a cut through this shoreline, but so far as observed does not disclose rock. Drifted sand hills of the Maumee level throughout this two mile stretch, are numerous, in one place rising above the 800-foot contour. Near the Ashtabula River the shoreline

Fig. 3. Cliff phase of the Whittlesey south of Ashtabula.

Fig. 4. The Whittlesey beach ridge built on the north face of the Painesville moraine, east of Ashtabula.

swings southward, in the vicinity of the cemetery; it is not likely that any considerable embayment characterized the Whittlesey shore at this point, though a slight depression apparently antedated the present river channel.

Immediately east of the river the shoreline consists of two ridges, for about one-half mile, a condition which also points to the presence of a small bay; in the southern of these two ridges, just west of the highway leading south to the river, a gravel pit has been opened. Thence eastward for nearly a mile, a single beach ridge obtains, built against the moraine (Fig. 4), which, in the early stages of the Whittlesey level, must have suffered much through wave-erosion. Eastward, near the margin of the sheet, the shoreline shows an inner ridge, barrier in origin.

Lake Arkona

Two shorelines, approximately 695 and 710 feet in altitude,[4] mark the levels of Lake Arkona, which was succeeded by Lake Whittlesey. Thus the Arkona beaches were submerged beneath 25 to 40 feet of water. Modified by wave-work and currents, these shorelines are quite indistinct, though in places well-defined beach fragments have withstood the attrition processes, and make it possible to trace the margin of Arkona waters.

East of Ashtabula is a mile segment of beach belonging to the lower stage of Lake Arkona; it is a few rods south of, and parallel with, the Warren beach. For three miles west of Ashtabula, between the Warren shoreline and the Electric railway, the map indicates a

[4]F. B. Taylor, Ann. Rep., Smithsonian Institution, 1912, p. 305.

fairly continuous sandy ridge. Throughout the next three miles westward this horizon of the Arkona is characterized by a continuous belt of sand in which dunes are numerous. Within two miles of Geneva two other fragments of the lower beach are shown. West of Geneva, near the border of the sheet, a short segment of the higher level is indicated; and several more segments of this stage are shown south of the Nickle Plate railway between Ashtabula and Geneva.

Lake Warren

Throughout much of this sheet, the Warren consists of a single beach ridge, about 680 feet in altitude; locally, an earlier but temporary position of the shoreline registered low fragmentary ridges, as shown on the western side where two segments are mapped as details of the main beach ridge. Bordering the Warren beach, in this vicinity, for nearly a mile, is a low rather flat ridge which belongs to Lake Wayne. From this point to Geneva the highway continues to follow the Warren beach, but east of the Lake Shore railway, the beach lies south of the street, and consists of gravel capped with sand.

Eastward from Geneva the highway to Ashtabula follows the Warren beach ridge which consists of gravel and sand, the latter increasing relatively toward Ashtabula. The ridge is rarely over six feet high; in the vicinity of Ashtabula, and along Prospect street in the city, the outer slope of the beach appears to have been steepened by wave-cutting shortly before this lake stage ended.

From the corporation limits of Ashtabula east to the Pennsylvania railway, the beach ridge is just north of Prospect street; between the railway and the river, this street appears to follow the crest rather than the back slope of the beach; the water slope shows some effects of wave-cutting; scattered areas of sand, some distance, north, suggest barrier beaches and shoal deposits.

The Ashtabula River has cut a gap slightly wider than its gorge, in the beach, the course of which on either side of the river indicates the absence of any bay at this point in the Warren shoreline. East of the river the course of the shoreline is marked by the highway leading to Conneaut. The outer slope of the beach is quite steep; near the margin of the sheet, sand on the beach-crest has been drifted into dunes.

Lake Wayne

Lake Warren was preceded by Lake Wayne, the shoreline of which lies 20 feet below that of Lake Warren. The Wayne shoreline

in consequence of this submergence consists of detached portions of beach ridges, usually washed down into broad swells of clayey sand, separated by long flat stretches over which there is sometimes a coating of sand, the only suggestion of wave-work.

East of Ashtabula the Conneaut highway follows the beach of Lake Warren. Close to and paralleling its north slope are several stretches of sand, somewhat arched, which might be interpreted as barriers of the Warren stage; more likely, however, these belong to Lake Wayne. The sand when examined closely does not resemble the loose-textured and more-easily-poured Warren sand.

Westward from Ashtabula the Lake Shore and Michigan Southern railway parallels a sandy tract which is very uniform in surface features; only one ridge segment has been indicated on the map, and this swell may be entirely of wind, rather than wave, origin, though its position suggests a barrier relationship to the Wayne beach.

Within the city limits of Ashtabula is a deposit of sand which may belong to Lake Warren, that is, of barrier origin; but its flat surface and content of clay suggest a washed-down Wayne beach. Commencing about a mile west of the city, the Wayne shoreline appears in disconnected ridges, low and sandy, parallel to the highway. West of Saybrook, the shoreline segments lie a little farther north of the Warren beach. In Geneva the Wayne appears to lie between the Lake Shore railway and Main street which follows the Warren beach. Another Wayne segment, about a mile long, is noted west of Wheeler Creek.

Lake Lundy

Grassmere Stage. For a mile on the east side of the sheet the highway, which is just north of the Lake Shore and Michigan Southern railway, follows the Grassmere beach ridge which consists of sand, and in places stands 6 to 8 feet above the general level. No more evidence of this shoreline is found east of the Ashtabula River nor within the first mile west of the river; the absence of wave-deposited materials may be the result of stream action. Thence westward a broad belt of sand, with an occasional segment of beach ridge, characterizes the level of this lake stage. Throughout a distance of three miles north of Saybrook even segments of sand are wanting. Nearing Geneva, however, the sandy belt bears numerous stretches of broken beaches; in no case, save where wind action has operated, are these ridges over three or four feet high.

Elkton Stage. This lower level of Lundy Lake is locally well-developed on the Ashtabula sheet. Proceeding from the east side one is unable to find any evidence of the Elkton beach east of the Lake Shore Club which occupies a position a few rods back from the present shore of Lake Erie and about one-half mile east of the Ashtabula River harbor. Here the beach ridge, consisting of clean medium-sized gravel, is very typical in cross-section. West of the harbor the ridge lies south of the Lake Road, and is continuous for a mile; thence westward it bears south from the Lake Road for about one-half mile, and again turns north to within a few rods of the highway, terminating near Red Brook. The sandy content of this beach increases the farther it is traced west from the Harbor.

After leaving Red Brook, for an interval of a mile and a half one finds no definite evidence of a shoreline. About two and one-half miles northwest of Saybrook there is a distinct crook in the course of Indian Creek; this irregularity in the stream is probably due to the Elkton beach. East of the creek is a low sandy beach segment, about one-half mile long, but in the vicinity of the stream no distinct shoreline appears today. The best evidence, however, of the former existence of a beach at this vicinity is the elbow in the course of the stream. The highway west of the creek crosses a low ridge of barrier sand. Between Indian and Cowles Creeks only one short segment of beach was noticed. West of Cowles Creek a sandy ridge is easily traced. West of Wheeler Creek the Elkton, for some distance, has a very distinct development; the sand on the land-side shows evidence of spreading by the wind.

THE PROGRESS OF GEOLOGY DURING THE PERIOD 1891-1915[1]

FRANK CARNEY

In every line of science some very important event may have culminated on a particular day. On the other hand, a twenty-five year interval may pass without recording a contribution of note, even though it were always possible to discern the highest merit; epoch making discoveries may not be recognized at once. Thus, as we members of the Ohio Academy of Science pass the first twenty-five year period of our history, and ask what has been accomplished in our individual fields of work, the answer may be sedately prosaic.

Pseudo-geologists. There was a time when one man knew as much as any other man about earth science, and home made geology was the only kind available. The output of this type of revelation has decreased relatively with the increase in the number of trained students, or of men with aptness for interpreting what they see. Nevertheless the last twenty-five years have recorded some extremely interesting specimens of pseudo-geology. The avenues of publication, which embrace a whole gamut of documents from the privately printed book to the widely read Sunday edition, give publicity to matter which finds no place in the documents of learned societies. Possibly we will always have the naive expounders of geological phenomena, men and women whose names may appear "often in paragraphs, seldom in monographs."

Pioneers in Geology. It has been the privilege of many of us to know a very few of these survivors from the early days of American geology, the versatile Patriarchs of a frontier stage. This type of teacher knew something of all sides of his study: as a chemist, he interpreted minerals from that point of view; he was a zoologist to the extent of knowing fossil forms as analogies or prototypes of living animals; he was a physiographer in recognizing the salient relationships between rock texture and structure and land forms; he was a geomorphologist because expected to account for the grosser anatomy

[1]Reprinted, with slight alterations, from the *Proceedings, Ohio Academy of Science*, vol. VI, part 5, 1916, pp. 299-308, an address read at the Quarter Centennial Anniversary of the Academy.

of the continents; he was a meteorologist since at that time no one else in the village communities or on the college faculties was thought to bear a closer relationship to the mysteries of the air; he was an anthropologist because fossils, hence all antiquities, belonged to his domain; and the public decreed that he was also an antiquarian. These men were promethean encyclopedias of facts, inspiring teachers, illuminating but unrecompensed prophets whose real compensation is the host of workers begot by their enthusiasm.

The sons of these pioneers, as is usual with the second generation, did not give disappointment by evincing greater wisdom than the fathers, and their grandsons feel no chagrin in not knowing completely any one of the numerous fields which the grandsires cultivated thoroughly. Thus has geology evolved specialists.

A comparison of the courses offered today and in the year 1890 by the Departments of Geology in our colleges and universities shows the results of specialization. No longer can the student listen to lectures on minerals, and mountain development, and mining, and paleontology, and petrography, given by the same man. The most modestly equipped university now has at least three groups in its geology courses; the more fully equipped have five or six groups. The tendency augurs further subdivision. It is not so long since the department of mineralogy did the work of the petrographer, but now our petrographers are splitting into several particular fields. In this subdivision of its work, geology and the other sciences accord with modern industry; and in the most highly organized industrial plants, the best machine does automatically just one thing. Possibly in the years to come, when all the little parcels of investigation have been thoroughly analyzed, the generations will begin to produce synthetically an end product that may bear some semblance to the pioneer in geology.

Text Books. The extensive geologic text of Eduard Suess, begun in the 80's, was completed a few years ago, not long before his death. This remarkable set of books has inspired emulation in several other countries. The comprehensive text of Geike in two volumes was very completely revised and republished in 1903. In this country a similar feat of scholarship has been accomplished by Chamberlin and Salisbury. It is doubtful whether we will have many more such texts. Geology as a science has become so subdivided, and so much detail worked out in each field, that a general

text book, to be complete, must be encyclopedic in size and would be little used except in libraries.

The last decade has witnessed the appearance of special books, each covering a particular field, as the dynamic, structural, tectonic, glacial, and paleontologic phases of the subject. Furthermore, special parts of these fields are beginning to have their individual manuals. This diversity of texts is to be expected as a result of the growing number of specialists in geology.

Periodicals. Twenty-five years ago, The American Geologist was the only American periodical in this field of science. In the year 1890, the Bulletin of the Geological Society of America began publication. Three years later the Journal of Geology was founded. In 1905, The American Geologist was incorporated with Economic Geology which first appeared in that year. The Bulletin of the Seismological Society of America dates from 1910. This large gain in the list of serials indicates an activity for which ample provision is not found in the publications of the federal and state surveys, or of learned societies.

United States Geological Survey. A national survey is a fair index of the status of geology in a country. Appropriations and men make a survey; an abundance of one can not at once offset a shortage of the other, but may tend to create an ample supply.

From 1890 to 1901 the lowest appropriation allowed the federal Survey any year was $494,640; the highest was $1,000,159.25; the average for the 12 years was $757,277.90. Since 1901, including 1916, the average annual appropriation was $1,544,048.33. In 1907 the irrigation work was withdrawn from the Survey, and in 1911 the Bureau of Mines was created relieving the Survey of certain technologic duties.

It is a matter of pride to all Americans that the United States Geological Survey now leads the nations in the quality of its topographic maps; but it is unfortunate that this work does not proceed more rapidly. If the rate of the last twenty-five years continues, nearly a century will pass before the map of our national area is completed. The general efficiency of its organization is also the envy of foreign workers. With us, as a general rule, politics, militarism, and geology mutually observe a decorous neutrality.

Progress in Economic Geology. In the early days of our state and federal surveys, the chief reason for their expenditure of public money was the securing of returns through the development of our

mineral resources. The results secured did not always satisfy the public. Consequently individuals and companies supported their own investigations. Later the surveys began to give more attention to economic minerals. The federal survey has become the chief authority on the mining and reduction of ores. Evidence of this leadership, is the fact that private corporations are drawing from the federal survey many of their highest salaried investigators.

The vastness of our mineral resources and the ease with which they are turned into wealth has encouraged careless and partial development. This falling short of possible accomplishment is keenly brought to our attention at the present time when the end results of certain hydrocarbon by-products, i. e., dyes, cannot be procured because Germany alone has carried such investigations to the highest industrial use. The same deficiency of development by Americans is also illustrated in the former exportation of radium minerals and other valuable ores which we preferred to sell raw. The present exigency in reference to dyes has aroused Americans, and should lead to a greater industrial independence; and the federal government, in co-operation with the American Radium Institute, an organization endowed for cancer investigation, is already successfully treating radium minerals and isolating the required radium salt. A further result of the present industrial condition in Europe is the hope that Americans may produce their own supply of potash salts and other ingredients in the manufacture of fertilizers; the federal survey is investigating the possibility of securing at least some of these supplies from our own minerals.

Bureau of Mines. The response of the government to the increasing need of assistance in developing and conserving our mineral resources is seen in the organization in 1911 of the Bureau of Mines. Previously this work was one of the lines of activity of the Geological Survey. In addition to investigating problems connected with the reduction of minerals and with non-wasteful methods of mining, this Bureau has attracted much attention through its efforts to avoid, and meliorate the disastrous effects of, mine accidents. Such work is conservation in the highest sense; it is much more excusable to waste minerals than men.

Alaska. In Alaska there is a larger percentage of government lands than in any other of the territories or states. In handling these lands the government can apply, usually without restraint, the most recent findings of its experts. Probably for this reason, the Geological

Survey has given special attention since 1896 to the mineral resources of Alaska, increasing the annual amount allowed for this study from $5,000 to $100,000. This field, therefore, offers the survey its freest opportunity for testing its best judgment on the development of mineral wealth. Complete harmony of opinion does not prevail in reference to the management of Alaska's mineral resources. The activity of private corporations in Alaska as well as the advice of experts acting for the government have led to contentions and much unpleasantness. Another generation will estimate more fairly these matters of dispute.

Mining Schools. The demand that college students might receive a training which would make them useful in mining operations led many years ago to the introduction of certain courses in mining, chiefly in technical institutions. Since then, departments of mining engineering have been established in other colleges. A later development is the founding of regular mining colleges. Within the last decade several large universities have organized schools of mining engineering, making use of courses already being offered and adding new courses to the several departments concerned. All of this development is indicative of the increasing demand for trained men in exploiting our mineral resources.

Work in Paleontology. This fundamental side of geology, oldest in popular interest, if not also in the development of the science, has made remarkable progress during the last twenty-five years. A measure of this progress is seen in the organization of the Paleontological Society in the year 1909, which works in co-operation with the Geological Society of America, of which, in reality, it is an out-growth.

The remarkable literature, both in volume and content, accumulated by paleontologists has necessitated the publishing of bibliographic indexes by the Federal Survey and the U. S. National Museum. The high standard of publications, particularly in the great expense required for the plates produced, by both the Federal and State Surveys, attests the sustained interest of the public, and the productiveness of the workers, in this field of geology.

Geological Survey of Ohio. The formation of the Third Survey of this state was almost coincident with the founding of the Ohio Academy of Science. When J. S. Newberry withdrew from the office of state geologist, the survey activities were placed in the hands of Edward Orton, Sr., who completed the work then under way, that is

volumes V and VI and "A Preliminary Report on Petroleum and Natural Gas," embracing in all 1931 pages, before proceeding with his own plans as state geologist. Professor Orton in addition to a report on Botany and another on Archeology, published about 1200 pages, divided almost equally between economic subjects, and stratigraphy and paleontology.

The Fourth Survey was formed in 1899 with Professor Edward Orton, Jr., as state geologist. Under his direction the survey published 1825 pages; 79.8% was devoted to economic geology, and of the remainder, 332 pages consisted of a bibliography of geologic papers relating to Ohio, and 36 pages were devoted to the "Nomenclature of geological formations."

In 1906 Professor John Adams Bownocker was appointed State Geologist. During the nine years to date, Professor Bownocker, in addition to a new geological map of Ohio, has published 2872 pages, apportioned as follows: historic, 45.9%; the economic, 51.9%; the remainder, physiographic. It should be noted, however, that other physiographic problems have been under investigation for several years. Under no other State Geologist have the activities of the Survey been more generally distributed among different phases of geology.

A New World Map. Federal geological organizations in the various countries have made it possible to consummate a proposal of the geographers. At a meeting of the Fifth International Geographical Congress at Bern, in 1891, a movement was initiated for the production of a standardized world map, on a scale of one to one million, i. e., about 15.78 statute miles to the inch. This was an optimistic proposal, the realization of which would require the cooperative interest of the several governments which are making maps of their territory. Slowly the idea took root; France, Germany, and England began to publish sheets on this scale. Following the Eighth Geographical Congress, which met in this country in 1904, our government through the Topographic Branch of the Geological Survey, commenced the issue of such sheets.

Uniformity in other respects than scale was insured by an agreement made at the Ninth Congress, which assembled in 1908 at Geneva, to use the polyconic projection, to reckon longitude from Greenwich, to have each sheet cover 4° of latitude and 6° of longitude, and to express altitude in intervals of 200 meters, though variations may be used in very flat and very mountainous regions.

This is a noteworthy example of international co-operation in science. Having a standard map of definite scale and projection, all the continents may be represented in their relative size; and from such standard maps larger or smaller ones may be drawn, giving a true representation, because the land areas will be shown in the same proportion.

Climate of the Geologic Past. Ecology teaches us today's correlation between organisms and their environment. We expect the most successful functioning of life forms only in a suitable combination of light, heat, moisture, food, and neighbors, a favorable habitat. In a dim way, students long ago recognized in the fossil record anomalies when referred to the present physical conditions of the fossil's geographical location. It was inferred, therefore, that in the progress of geologic time there have come changes in climate, or at least in the distribution of mean annual temperature, in particular parts of the earth's surface. A similar inference has been drawn from wide-spread glaciation. Both deductions are rather broad generalizations.

Since 1890 there has been a tendency in these matters to seek the concrete and specific. Wherever possible more exact methods have been applied to the hazy interpretations of the past. This application is limited, for the present at least, to the recent geologic past, and the corroboration of human history, wherever possible, adds welcome conviction. Thus is the field exceedingly limited. However, encouraging results have been secured particularly through the work of Ellsworth Huntington in a study of strand lines, and of the growth made by very old trees, the sequoias; the latter respond to, and, in their rings of seasonal growth, register the conditions of moisture; the former register variations in the level of water bodies in inland basins. Quite recently, Mr. Huntington is attempting to correlate the precipitates of desiccating water with the other two lines of evidence.

This type of investigation is producing results which accord with the deductions made by the paleontologist from the expanding, dwarfing, or disappearance of faunas; it throws light on the origin of gypsum and other locally deposited salts; and helps to elucidate several stratigraphic features.

The Age of the Earth. When one arrays the estimates of this sphere's antiquity, made by workers in various phases of science, he must conclude that mother earth is either a coy maiden, an indifferent

matron, or a gibbering old woman. The margin of safety in these guesses is about one billion years.

In 1862 Lord Kelvin, studying the thermal conductivity of the sphere, decided that the earth is at least 20 million and not over 400 million years old. After an interval of 35 years he amended these figures somewhat and stated, in concurrence with Clarence King's assertion, that about 24 million years ago the earth was a molten mass.

Sir George Darwin in 1886 had urged the wisdom of considering "Theories which appear to demand longer periods of time than those which now appear allowable." Ten years ago he suggested again that the physicists may be in error in computing the age of the earth, and said: "The scale of geological rime remains in great measure unknown."

From the thickness of sediments, and the rate at which rivers are making deposits, Charles D. Walcott in 1893 reckoned the lapse of time since the beginning of the Archean to be 90 million years.

Professor John Joly in 1899, from computations of the quantity of sodium in the oceans and their annual accession of sodium, stated the probable age of the earth to be from 90 to 100 million years.

Students of biology have preferred a great length of time for the complex results of evolution. The estimates made by physicists, chemists, and some geologists appear inadequate to them.

Since the discovery of radium, and a more general investigation of radio-active minerals and derivatives from radium, the evolutionists have taken hope. No line of investigation has been so profligate with time as that concerning radio-activity. John Allen Harker, the British physicist, says, "a study of the various radio-active elements contained in minerals and rocks has shown that it is possible, in certain favorable cases, to calculate directly their ages in years." Thus calculated, the Archean rocks are from one billion to one billion, six hundred million years old.

Over a hundred years ago, Hutton, speaking as do the poets and the prophets in science, asserted that geologic time had "no vestige of a beginning, no prospect of an end."

Theories of Earth-Origin. Twenty-five years ago one seldom heard any question raised about the satisfactoriness of the nebular hypothesis. More recently certain variations in this hypothesis have been proposed, but the fundamentals of the Laplacian theory have place in all these restatements. Necessarily, modifications should

follow upon the findings of the spectroscope and photograph-attachments of the large telescopes, instruments that were scarcely dreamed of in the day of the French savant.

Among the contributions made to geology since the organization of this Academy none is greater than that of T. C. Chamberlin arising from his critical examination of the various hypotheses for the origin of the solar system. Chamberlin's "Planetesimal Hypothesis," in the estimation of one who has studied his several papers from the related series beginning with, "A Group of Hypotheses Bearing on Climatic Changes" (*Journal of Geology*, Vol. V (1897), pp. 653; Vol. VII, pp. 545-584, 667-685, 751-787) is largely a by-product of his studies in reference to the origin of the atmosphere. This fact illustrates how interwoven and interdependent are the various phases of truth.

The simplicity of the Laplacian theory, and its accordance with all that was then known about the planetary system, the vastness of its generalizations, and the meager knowledge of the fundamentals in any theory of earth-origin, led to its immediate and almost universal acceptance. So long has this theory been taught that the idea of a once molten sphere has become a premise, almost an axiom, and is made fundamental in explaining mountains, volcanic activity, and in petrographical studies. The dissent from its teachings is still very local, as is a studious interest in any alternative theory. Conservatism is the armor, as well as the embalming fluid, of science.

That the planetesimal theory as now stated, or slightly modified, will in time be generally accepted, is the belief of most men who have made themselves acquainted with the basis of study from which this theory developed. In our generation no greater contribution has been made to theoretical geology.